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ISSN 0262 3617

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COMMENTS ... POPULAR FEATURES ...

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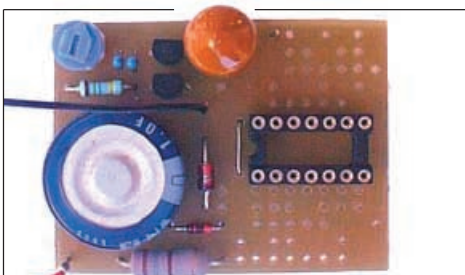
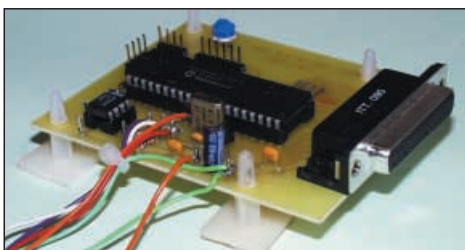
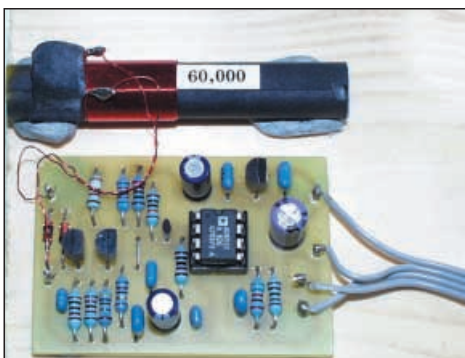
Cover illustration by Jonathan Robertson

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WE HAVE MOVED!

Please note our new address and
phone/fax numbers – see page 471

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NEXT MONTH

DIGITIMER

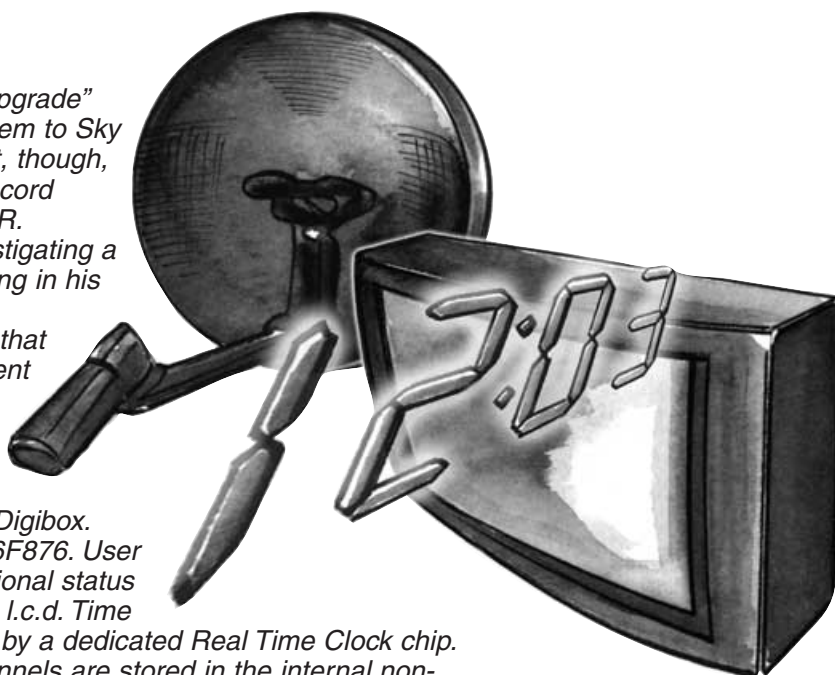
The author was persuaded to "upgrade" his motorised Pace satellite system to Sky Digital. It soon became apparent, though, that its Digibox did not have a record timer feature for use with his VCR.

Consequently he set about investigating a suitable external solution, resulting in his Digitimer constructional design.

The concept behind Digitimer is that at a preset time the Digibox is sent a series of remote control commands to change to the desired channel. They can be sent either via infra-red or via r.f.

to the Digilink connector on the Digibox.

The unit is controlled by a PIC16F876. User input is via a keypad and operational status is displayed on an alphanumeric l.c.d. Time keeping functions are controlled by a dedicated Real Time Clock chip. Timer settings and favourite channels are stored in the internal non-volatile EEPROM.



COMPACT SHORTWAVE LOOP AERIAL

Some readers who constructed the Active Ferrite Loop Aerial (Sept '00) have asked if its coverage can be extended to the shortwave bands.

A new circuit has, therefore, been developed for reception between 1.6MHz and 30MHz. Although similar in concept to the medium wave version, plug-in air-cored loops are used, modifications have been made to the tuning and Q-multiplier circuits, and a second buffer stage has been incorporated. In addition to making the operation of the controls smoother at high frequencies, the extra stage also provides signal amplification.

This Q-multiplied loop aerial will deliver as much signal as a long wire and null out local electrical interference. Performance, in terms of signal output and depth of null, is very satisfactory.

PERPETUAL PROJECTS – 2

The Sun can flash an l.e.d. forever! This simple solar-powered flasher could be used as a thief deterrent almost anywhere – maybe on a dummy bell box or in an outbuilding etc. Or use it to mark a switch or keyhole so you can find it at night. The second project (yes, two next month) is a Double Door Buzzer; not for double-doors, but to give different tones for two doors. Again it will run forever on solar power.

PLUS ALL THE REGULAR FEATURES

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AUGUST 2001 ISSUE ON SALE THURSDAY, JULY 12

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FREE CATALOGUE with order or £2 x 1st class stamps (refundable) for details of over 150 kits & publications.



PROJECT KITS

Our electronic kits are supplied complete with all components, high quality PCBs (NOT cheap Tripad strip board!) and detailed assembly/operating instructions

- **2 x 25W CAR BOOSTER AMPLIFIER** Connects to the output of an existing car stereo cassette player, CD player or radio. Heatsinks provided. PCB 76x55mm. **1046KT £24.95**
- **3-CHANNEL WIRELESS LIGHT MODULATOR** No electrical connection with amplifier. Light modulation achieved via a sensitive electret microphone. Separate sensitivity control per channel. Power handling 400W/channel. PCB 54x112mm. Mains powered. Box provided. **6014KT £24.95**
- **12 RUNNING LIGHT EFFECT** Exciting 12 LED light effect ideal for parties, discos, shop-windows & eye-catching signs. PCB design allows replacement of LEDs with 220V bulbs by inserting 3 TRIACS. Adjustable rotation speed & direction. PCB 54x112mm. **1026KT £15.95; BOX (for mains operation) £20.95**
- **DISCO STROBE LIGHT** Probably the most exciting of all light effects. Very bright strobe tube. Adjustable strobe frequency: 1-60Hz. Mains powered. PCB: 60x88mm. Box provided. **6037KT £28.95**

- **ANIMAL SOUNDS** Cat, dog, chicken & cow. Ideal for kids farmyard toys & schools. **SG10M £5.95**
- **3 1/2 DIGIT LED PANEL METER** Use for basic voltage/current displays or customise to measure temperature, light, weight, movement, sound levels, etc. with appropriate sensors (not supplied). Various input circuit designs provided. **3061KT £13.95**
- **IR REMOTE TOGGLE SWITCH** Use any TV/VCR remote control unit to switch onboard 12V/1A relay on/off. **3058KT £10.95**
- **SPEED CONTROLLER** for any common DC motor up to 100V/5A. Pulse width modulation gives maximum torque at all speeds. 5-15VDC. Box provided. **3067KT £12.95**
- **3 x 8 CHANNEL IR RELAY BOARD** Control eight 12V/1A relays by Infra Red (IR) remote control over a 20m range in sunlight. 8 relays turn on only, the other 2 toggle on/off. 3 operation ranges determined by jumpers. Transmitter case & all components provided. Receiver PCB 76x89mm. **3072KT £52.95**

PRODUCT FEATURE

4 WATT FM TRANSMITTER

Small but powerful 4 Watt 88-108MHz FM transmitter with an audio preamplifier stage and 3 RF stages. Accepts a wide variety of input sources – the electret microphone supplied, a tape player or for more professional results, a separate audio mixer (like our 3-Input Mono Mixer kit 1052). Can be used with an open dipole or ground plane antenna. Supply: 12-15V DC/0-5A. PCB: 45 x 145mm.

ORDERING INFO: Kit 1028KT £22.95.
OPTIONAL EXTRAS: 3-Input Mono Mixer Kit 1052KT £17.95. AS1028 £39.95.



- **SOUND EFFECTS GENERATOR** Easy to build. Create an almost infinite variety of interesting/unusual sound effects from birds chirping to sirens. 9VDC. PCB 54x85mm. **1045KT £8.95**
- **ROBOT VOICE EFFECT** Make your voice sound similar to a robot or Darlek. Great fun for discos, school plays, theatre productions, radio stations & playing jokes on your friends when answering the phone! PCB 42x71mm. **1131KT £8.95**
- **AUDIO TO LIGHT MODULATOR** Controls intensity of one or more lights in response to an audio input. Safe, modern opto-coupler design. Mains voltage experience required. **3012KT £8.95**
- **MUSIC BOX** Activated by light. Plays 8 Christmas songs and 5 other tunes. **3104KT £7.95**
- **20 SECOND VOICE RECORDER** Uses non-volatile memory - no battery backup needed. Record/replay messages over & over. Playback as required to greet customers etc. Volume control & built-in mic. 6VDC. PCB 50x73mm. **3131KT £12.95**
- **TRAIN SOUNDS** 4 selectable sounds: whistle blowing, level crossing bell, 'clackety-clack' & 4 in sequence. **SG01M £6.95**

- **PC CONTROLLED RELAY BOARD** Convert any 286 upward PC into a dedicated automatic controller to independently turn on/off up to eight lights, motors & other devices around the home, office, laboratory or factory using 8 240VAC/12A onboard relays. DOS utilities, sample test program, full-featured Windows utility & all components (except cable) provided. 12VDC. PCB 70x200mm. **3074KT £31.95**
- **2 CHANNEL UHF RELAY SWITCH** Contains the same transmitter/receiver pair as 30A15 below plus the components and PCB to control two 240VAC/10A relays (also supplied). Ultra bright LEDs used to indicate relay status. **3082KT £27.95**
- **TRANSMITTER RECEIVER PAIR** 2-button keyfob style 300-375MHz Tx with 30m range. Receiver encoder module with matched decoder IC. Components must be built into a circuit like kit 3082 above. **30A15 £14.95**
- **PIC 16C71 FOUR SERVO MOTOR DRIVER** Simultaneously control up to 4 servo motors. Software & all components (except servos/control pots) supplied. 5VDC. PCB 50x70mm. **3102KT £15.95**
- **UNIPOLAR STEPPER MOTOR DRIVER** for any 5/6/8 lead motor. Fast/slow & single step rates. Direction control & on/off switch. Wave, 2-phase & half-wave step modes. 4 LED indicators. PCB 50x65mm. **3109KT £14.95**
- **PC CONTROLLED STEPPER MOTOR DRIVER** Control two unipolar stepper motors (3A max. each) via PC printer port. Wave, 2-phase & half-wave step modes. Software accepts 4 digital inputs from external switches & will single step motors. PCB fits in D-shell case provided. **3113KT £17.95**
- **12-BIT PC DATA ACQUISITION/CONTROL UNIT** Similar to kit 3093 above but uses a 12 bit Analogue-to-Digital Converter (ADC) with internal analogue multiplexer. Reads 8 single ended channels or 4 differential inputs or a mixture of both. Analogue inputs read 0-4V. Four TTL/CMOS compatible digital input/outputs. ADC conversion time <10µs. Software (C, QB & Win), extended D shell case & all components (except sensors & cable) provided. **3118KT £52.95**
- **LIQUID LEVEL SENSOR/RAIN ALARM** Will indicate fluid levels or simply the presence of fluid. Relay output to control a pump to add/remove water when it reaches a certain level. **1080KT £5.95**
- **AM RADIO KIT** 1 Tuned Radio Frequency front-end, single chip AM radio IC & 2 stages of audio amplification. All components inc. speaker provided. PCB 32x102mm. **3063KT £10.95**
- **DRILL SPEED CONTROLLER** Adjust the speed of your electric drill according to the job at hand. Suitable for 240V AC mains powered drills up to



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- **LOCKS** - How they work and how to pick them. This fact filled report will teach you more about locks and the art of lock picking than many books we have seen at 4 times the price. Packed with information and illustrations. **R006 £3.50**
- **RADIO & TV JOKER PLANS** We show you how to build three different circuits for disrupting TV picture and sound plus FM radio! May upset your neighbours & the authorities!! DISCRETION REQUIRED. **R017 £3.50**
- **INFINITY TRANSMITTER PLANS** Complete plans for building the famous Infinity Transmitter. Once installed on the target phone, device acts like a room bug. Just call the target phone & activate the unit to hear all room sounds. Great for home/office security! **R019 £3.50**
- **THE ETHER BOG CALL INTERCEPTOR PLANS** Grabs telephone calls out of thin air! No need to wire-in a phone bug. Simply place this device near the phone lines to hear the conversations taking place! **R025 £3.00**
- **CASH CREATOR BUSINESS REPORTS** Need ideas for making some cash? Well this could be just what you need! You get 40 reports (approx. 800 pages) on floppy disk that give you information on setting up different businesses. You also get valuable reproduction and duplication rights so that you can sell the manuals as you like. **R030 £7.50**

SURVEILLANCE

High performance surveillance bugs. Room transmitters supplied with sensitive electret microphone & battery holder/clip. All transmitters can be received on an ordinary VHF/FM radio between 88-108MHz. Available in Kit Form (KT) or Assembled & Tested (AS).

ROOM SURVEILLANCE

- **MTX - MINIATURE 3V TRANSMITTER** Easy to build & guaranteed to transmit 300m @ 3V. Long battery life. 3-5V operation. Only 45x18mm. **B 3007KT £6.95 AS3007 £11.95**
- **MRTX - MINIATURE 9V TRANSMITTER** Our best selling bug. Super sensitive, high power - 500m range @ 9V (over 1km with 18V supply and better aerial). 45x18mm. **3018KT £7.95 AS3018 £12.95**
- **HPTX - HIGH POWER TRANSMITTER** High performance, 2 stage transmitter gives greater stability & higher quality reception. 1000m range 6-12V DC operation. Size 70x15mm. **3032KT £9.95 AS3032 £18.95**
- **MMTX - MICRO-MINIATURE 9V TRANSMITTER** The ultimate bug for its size, performance and price. Just 15x25mm. 500m range @ 9V. Good stability. 6-18V operation. **3051KT £8.95 AS3051 £14.95**
- **VTX - VOICE ACTIVATED TRANSMITTER** Operates only when sounds detected. Low standby current. Variable trigger sensitivity. 500m range. Peaking circuit supplied for maximum RF output. On/off switch. 6V operation. Only 63x38mm. **3028KT £12.95 AS3028 £21.95**
- **HARDWIRED BUG/TWO STATION INTERCOM** Each station has its own amplifier, speaker and mic. Can be set up as either a hard-wired bug or two-station intercom. 10m x 2-core cable supplied. 9V operation. **3021KT £15.95 (kit form only)**
- **TRVS - TAPE RECORDER VOX SWITCH** Used to automatically operate a tape recorder (not supplied) via its REMOTE socket. When sounds are detected. All conversations recorded. Adjustable sensitivity & turn-off delay. 115x19mm. **3013KT £9.95 AS3013 £21.95**



TELEPHONE SURVEILLANCE

- **MTTX - MINIATURE TELEPHONE TRANSMITTER** Attaches anywhere to phone line. Transmits only when phone is used! Tune-in your radio and hear both parties. 300m range. Uses line as aerial & power source. 20x45mm. **3016KT £8.95 AS3016 £14.95**
- **TRT - TELEPHONE RECORDING INTERFACE** Automatically record all conversations. Connects between phone line & tape recorder (not supplied). Operates recorders with 1.5-12V battery systems. Powered from line. 50x33mm. **3033KT £9.95 AS3033 £18.95**
- **TPA - TELEPHONE PICK-UP AMPLIFIER/WIRELESS PHONE BUG** Place pick-up coil on the phone line or near phone earpiece and hear both sides of the conversation. **3055KT £11.95 AS3055 £20.95**
- **HIGH POWER TRANSMITTERS**
- **1 WATT FM TRANSMITTER** Easy to construct. Delivers a crisp, clear signal. Two-stage circuit. Kit includes microphone and requires a simple open dipole aerial. 6-30VDC. PCB 42x45mm. **1009KT £14.95**
- **4 WATT FM TRANSMITTER** Comprises three RF stages and an audio preamplifier stage. Piezoelectric microphone supplied or you can use a separate preamplifier circuit. Antenna can be an open dipole or Ground Plane. Ideal project for those who wish to get started in the fascinating world of FM broadcasting and want a good basic circuit to experiment with. 12-18VDC. PCB 44x146mm. **1028KT £22.95 AS1028 £34.95**
- **15 WATT FM TRANSMITTER (PRE-ASSEMBLED & TESTED)** Four transistor based stages with Philips BLY 88 in final stage. 15 Watts RF power on the air. 88-108MHz. Accepts open dipole. Ground Plane. 5/8, J, or YAGI antennas. 12-18VDC. PCB 70x220mm. SWS meter needed for alignment. **1021KT £99.95**
- **SIMILAR TO ABOVE BUT 25W Output.** **1031KT £109.95**

- 700W power. PCB: 48mm x 65mm. Box provided. **6074KT £17.95**
- **3 INPUT MONO MIXER** Independent level control for each input and separate bass/treble controls. Input sensitivity: 240mV. 18V DC. PCB: 60mm x 185mm. **1052KT £16.95**
- **NEGATIVE/POSITIVE ION GENERATOR** Standard Cockcroft-Walton multiplier circuit. Mains voltage experience required. **3057KT £10.95**
- **LED DICE** Classic intro to electronics & circuit analysis. 7 LEDs simulate dice roll, slow down & land on a number at random. 555 IC circuit. **3003KT £9.95**
- **STAIRWAY TO HEAVEN** Tests hand-eye co-ordination. Press switch when green segment of LED lights to climb the stairway - miss & start again! Good intro to several basic circuits. **3005KT £9.95**
- **ROULETTE LED 'Ball'** spins round the wheel, slows down & drops into a slot. 10 LEDs. Good intro to CMOS decade counters & Op-Amps. **3006KT £10.95**
- **9V XENON TUBE FLASHER** Transformer circuit steps up 9V battery to flash a 25mm Xenon tube. Adjustable flash rate (0.25-2 Sec's). **3022KT £11.95**
- **LED FLASHER 1** 5 ultra bright red LEDs flash in 7 selectable patterns. **3037MKT £5.95**
- **LED FLASHER 2** Similar to above but flash in sequence or randomly. Ideal for model railways. **3052MKT £5.95**
- **INTRODUCTION TO PIC PROGRAMMING.** Learn programming from scratch. Programming hardware, a P16F84 chip and a two-part, practical, hands-on tutorial series are provided. **3081KT £22.95**
- **SERIAL PIC PROGRAMMER** for all 818/28/40 pin DIP serial programmed PICs. Shareware software supplied limited to programming 256 bytes (registration costs £14.95). **3096KT £13.95**
- **ATMEL 89C051 PROGRAMMER** Simple-to-use yet powerful programmer for the Atmel 89C051, 89C2051 & 89C4051 uCs. Programmer does NOT require special software other than a terminal emulator program (built into Windows). Can be used with ANY computer/operating system. **3121KT £24.95**
- **3V/1-5V TO 9V BATTERY CONVERTER** Replace expensive 9V batteries with economic 1.5V batteries. IC based circuit steps up 1 or 2 'AA' batteries to give 9V/18mA. **3035KT £5.95**
- **STABILISED POWER SUPPLY 3-30V/2.5A** Ideal for hobbyist & professional laboratory. Very reliable & versatile design at an extremely reasonable price. Short circuit protection. Variable DC voltages (3-30V). Rated output 2.5 Amps. Large heatsink supplied. You just supply a 24VAC/3A transformer. PCB 55x112mm. Mains operation. **1007KT £16.95.**

- **STABILISED POWER SUPPLY 2-30V/5A** As kit 1007 above but rated at 5Amp. Requires a 24VAC/5A transformer. **1096KT £27.95.**
- **MOTORBIKE ALARM** Uses a reliable vibration sensor (adjustable sensitivity) to detect movement of the bike to trigger the alarm & switch the output relay to which a siren, bikes horn, indicators or other warning device can be attached. Auto-reset. 6-12VDC. PCB 57x64mm. **1011KT £11.95 Box 2011BX £7.00**
- **CAR ALARM SYSTEM** Protect your car from theft. Features vibration sensor, courtesy/boot light voltage drop sensor and bonnet/boot earth switch sensor. Entry/text delays, auto-reset and adjustable alarm duration. 6-12V DC. PCB: 47mm x 55mm. **1019KT £11.95 Box 2019BX £8.00**
- **PIEZO SCREAMER** 110dB of ear piercing noise. Fits in box with 2 x 35mm piezo elements built into their own resonant cavity. Use as an alarm siren or just for fun! 6-9VDC. **3016KT £10.95**
- **COMBINATION LOCK** Versatile electronic lock comprising main circuit & separate keypad for remote opening of lock. Relay supplied. **3029KT £10.95**
- **ULTRASONIC MOVEMENT DETECTOR** Crystal locked detector frequency for stability & reliability. PCB 75x40mm houses all components. 4-7m range. Adjustable sensitivity. Output will drive external relay/circuits. 9VDC. **3049KT £13.95**
- **PIR DETECTOR MODULE** 3-lead assembled unit just 25x35mm as used in commercial burglar alarm systems. **3076KT £8.95**
- **INFRARED SECURITY BEAM** When the invisible IR beam is broken a relay is tripped that can be used to sound a bell or alarm. 25 metre range. Mains rated relays provided. 12VDC operation. **3130KT £12.95**
- **SQUARE WAVE OSCILLATOR** Generates square waves at 6 preset frequencies in factors of 10 from 1Hz-100KHz. Visual output indicator. 5-18VDC. Box provided. **3111KT £8.95**
- **PC DRIVEN POCKET SAMPLER/DATA LOGGER** Analogue voltage sampler records voltages up to 2V or 20V over periods from milli-seconds to months. Can also be used as a simple digital scope to examine audio & other signals up to about 5KHz. Software & D-shell case provided. **3121KT £18.95**
- **20 MHz FUNCTION GENERATOR** Square, triangular and sine waveform up to 20MHz over 3 ranges using 'coarse' and 'fine' frequency adjustment controls. Adjustable output from 0-2V p-p. A TTL output is also provided for connection to a frequency meter. Uses MAX038 IC. Plastic case with printed front/rear panels & all components provided. 7-12VAC. **3101KT £69.95**

BARGAIN BUY!

Great introduction to electronics. Ideal for the budding electronics expert! Build a radio, burglar alarm, water detector, Morse code practice circuit, simple computer circuits, and much more! NO soldering, tools or previous electronics knowledge required. Circuits can be built and unassembled repeatedly. Comprehensive 68-page manual with explanations, schematics and assembly diagrams. Suitable for age 10+. Excellent for schools. Requires 2 x AA batteries. **ONLY £14.95** (phone for bulk discounts).

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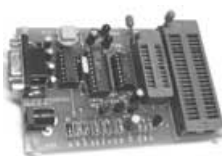
'PICALL' PIC Programmer

Kit will program **ALL** 8*, 18*, 28 and 40 pin serial AND parallel programmed PIC micro controllers. Connects to PC parallel port. Supplied with fully functional pre-registered PICALL DOS and WINDOWS AVR software packages, all components and high quality DSPTH PCB. Also programs certain ATMEL AVR, serial EPROM 24C and SCENIX SX devices. New PIC's can be added to the software as they are released. Software shows you where to place your PIC chip on the board for programming. Now has blank chip auto sensing feature for super-fast bulk programming. *A 40 pin wide ZIF socket is required to program 8 & 18 pin devices (available at £15.95).



Order Ref	Description	Inc. VAT ea
3117KT	'PICALL' PIC Programmer Kit	£59.95
AS3117	Assembled 'PICALL' PIC Programmer	£69.95
AS3117ZIF	Assembled 'PICALL' PIC Programmer c/w ZIF socket	£84.95

ATMEL 89xxxx Programmer



Powerful programmer for Atmel 8051 micro controller family. All fuse and lock bits are programmable. Connects to serial port. Can be used with ANY computer & operating system. 4 LEDs to indicate programming status. Supports 89C1051, 89C2051, 89C4051, 89C51, 89LV51, 89C52, 89LV52, 89C55, 89LV55, 89S8252, 89LS8252, 89S53 & 89LS53 devices. NO special software required - uses any terminal emulator program (built into Windows). **NB ZIF sockets not included.**

Order Ref	Description	Inc. VAT ea
3123KT	ATMEL 89xxx Programmer	£32.95
AS3123	Assembled 3123	£47.95

Atmel 89C051 and AVR programmers also available.

PC Data Acquisition & Control Unit

With this kit you can use a PC parallel port as a real world interface. Unit can be connected to a mixture of analogue and digital inputs from pressure, temperature, movement, sound, light intensity, weight sensors, etc. (not supplied) to sensing switch and relay states. It can then process the input data and use the information to control up to 11 physical devices such as motors, sirens, other relays, servo motors & two-stepper motors.



FEATURES:

- 8 Digital Outputs: Open collector, 500mA, 33V max.
 - 16 Digital Inputs: 20V max. Protection 1K in series, 5-1V Zener to ground.
 - 11 Analogue Inputs: 0-5V, 10 bit (5mV/step.)
 - 1 Analogue Output: 0-2.5V or 0-10V. 8 bit (20mV/step.)
- All components provided including a plastic case (140mm x 110mm x 35mm) with pre-punched and silk screened front/rear panels to give a professional and attractive finish (see photo) with screen printed front & rear panels supplied. Software utilities & programming examples supplied.

Order Ref	Description	Inc. VAT ea
3093KT	PC Data Acquisition & Control Unit	£99.95
AS3093	Assembled 3093	£124.95

See opposite page for ordering information on these kits

ABC Mini 'Hotchip' Board

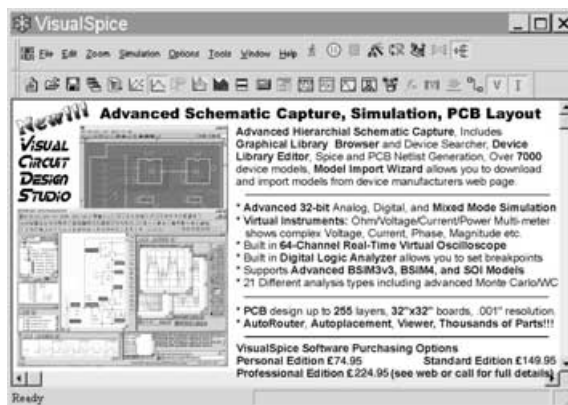


Currently learning about microcontrollers? Need to do something more than flash a LED or sound a buzzer? The ABC Mini 'Hotchip' Board is based on Atmel's AVR 8535 RISC technology and will interest both the beginner and expert alike. Beginners will find that they can write and test a simple program, using the BASIC programming language, within an hour or two of connecting it up.

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Order Ref	Description	Inc. VAT ea
ABCMINISP	ABC MINI Starter Pack	£64.95
ABCMINIB	ABC MINI Board Only	£39.95

Advanced Schematic Capture and Simulation Software



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Order Ref	Description	Inc. VAT
3108KT	Serial Port Isolated I/O Controller Kit	£54.95
AS3108	Assembled Serial Port Isolated I/O Controller	£69.95

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STRM STRS SV1 T TA TAA TAG TBA TC TCA TDA TDB
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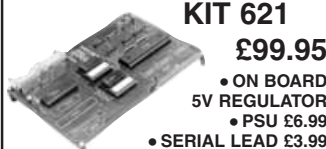
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Based on February '96 EPE. Magenta designed PCB and kit. PCB with 'Reset' switch, Program switch, 5V regulator and test L.E.D.s, and connection points for access to all A and B port pins.

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INCLUDES 1-PIC16F84 WITH
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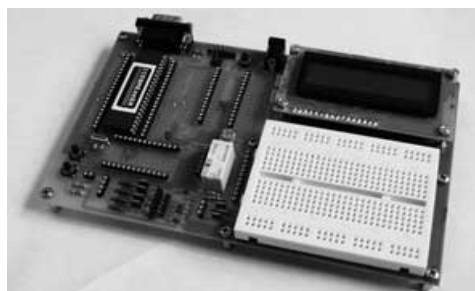
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Includes: PIC16F84 Chip, TOP Quality PCB printed with Component Layout and all components* (*not ZIF Socket or Displays). Included with the Magenta Kit is a disk with Test and Demonstration routines.

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Optional: **Power Supply – £3.99, ZIF Socket – £9.99**

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Reprints Mar/Apr/May 98 – £3.00 set 3

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SOFTWARE DISC,
INSTRUCTIONS
AND MOTOR.

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FULL SOURCE CODE SUPPLIED
ALSO USE FOR DRIVING OTHER
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8-CHANNEL DATA LOGGER

As featured in Aug./Sept. '99 EPE. Full kit with Magenta redesigned PCB – LCD fits directly on board. Use as Data Logger or as a test bed for many other 16F877 projects. Kit includes programmed chip, 8 EEPROMs, PCB, case and all components.

KIT 877 £49.95 inc. 8 x 256K EEPROMS

MAGENTA

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Everyday Practical Electronics, July 2001

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WE'VE GONE

By the time you read this we won't be there! Again? someone asked me the other day. Well it is seven years since we did it last and seven years before that – and seven . . . Yes, it has become repetitive and the interesting thing is that something significant has happened to the magazine roughly every seven years since the birth of *PE* back in 1964. If you care to read *The History of EPE* on our UK web site you will get the full picture.

The last time we moved our UK editorial office it was into larger premises to accommodate our expanding publishing "empire", this time it is for commercial reasons (we will own the building). Of course, the message we need to get across is that even though we are not there anymore it's business as usual, so please note our new address, telephone and fax numbers. Anything sent to the old address will be redirected by the Post Office but, of course, it may be delayed in that process.

WE'RE STAYING

The move does not affect our advertising office so please continue to use the same address and telephone numbers for Peter Mew – our Advertisement Manager. Also all the E-mail and web site addresses remain unchanged, thanks to technology – pity technology won't yet allow us to keep our editorial phone and fax numbers, even though we are only moving about three miles up the road.

PLCs

Programmable Logic Controllers (PLCs) are a subject that readers have occasionally asked us about. They are presently only really of interest to those in industry where they are used to control a vast range of manufacturing processes. Because of this, we do not feel that in-depth articles on these devices are appropriate for *EPE*. However, Owen Bishop's article in this issue gives an overview of what they are, how they work and where they might be used. We hope it helps your understanding.

SUN'S UP

This issue also sees the start of an interesting series of *Perpetual Projects* powered by the sun. The research that the designer has undertaken to reduce circuit power consumption has thrown up some interesting results that could be of use to any designer. Even if the projects themselves are not of interest to you, the opening part of the series is well worth reading. (As if you would not read every page of *EPE* anyway!)

Mike Kenward

AVAILABILITY

Copies of *EPE* are available on subscription anywhere in the world (see below), from all UK newsagents (distributed by COMAG) and from the following electronic component retailers: Omni Electronics and Yebbo Electronics (S. Africa). *EPE* can also be purchased from retail magazine outlets around the world. An Internet on-line version can be purchased and downloaded for just \$9.99(US) per year available from www.epemag.com

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COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers (see *Shoptalk*). We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

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STEREO/ SURROUND SOUND AMPLIFIER



MAX HORSEY and TOM WEBB

An inexpensive, easy to build, stereo amplifier that can also produce pseudo surround sound when used with an existing stereo amplifier.

Gives a "true" 1W r.m.s. per channel output from a 12V supply

THIS Stereo/Surround Sound Amplifier is a simple system based on a TDA2822M amplifier i.c. and is rated at 1 watt per channel. At first sight this may appear puny, but note that this is a *genuine* watt, in other words it is an r.m.s. measurement. When driven from a 12V supply there will be plenty of sound.

FIGURES AND LIES

There are a number of different ways of measuring the power output from an amplifier. A good Hi-Fi store will only quote r.m.s. figures. These are mathematically based and provide a clear and accurate guide to the output.

Some dealers may prefer to quote "Peak Power". This is higher than r.m.s. power. Another misleading term is "Music Power" (whatever that means), but the most outstanding use of phoney figures must be "Peak Music Power Output (PMPO)".

Many computer speakers with integral amplifiers are quoted in terms of PMPO. When the author bought a pair of computer speakers with internal amplifiers rated at 100W PMPO, the actual r.m.s. power was found to be *less than 1W*.

ANOTHER MYSTERY

Another wattage mystery is how the power output actually affects the loudness of the sound. You may think that 2W (r.m.s.) will be twice as loud as 1W (r.m.s.). This is not the case, since power output needs to be many times higher for an appreciable increase in loudness. So you would need to increase to 10W to notice much difference. Put another way, 1W (r.m.s.) per channel will sound much louder than the figure implies.

SYSTEM DETAILS

The block diagram of the Stereo/Surround Sound Amplifier system is illustrated in Fig.1. Note that this project only comprises of the parts within the heavy borders. The other blocks represent your existing system.

The amplifier is designed to amplify a stereo Line signal from any standard source such as a CD-player, tuner, video recorder, mini disc player. It does not include a pre-amplifier and is therefore *not* suitable for a record deck or microphone.

SURROUND SOUND

If you already have a stereo amplifier, then this 1W amplifier project may be used to extract a *pseudo* surround sound signal, and the p.c.b. includes provision for additional resistors and a capacitor i.e. the Surround Sound Extractor.

The cost of the surround sound components is less than 50p, and should not be confused with Dolby Surround, Dolby Pro-Logic, Dolby Digital, or DTS sound!

But the effect – considering the modest cost – is quite convincing.

When hooked up to an existing amplifier, our surround extractor amplifies the difference between the signals applied to the main stereo speakers. If the sound is coming from the centre, the two stereo speakers will be delivering identical signals, and these will not be amplified by the extractor. If the main stereo speakers are 180 degrees out of phase, the sound will be amplified by the extractor and delivered via the rear speakers.

Of course, the sound field will not be as accurate as a fully-fledged surround sound processor, but it will be much better than driving rear speakers in parallel with the front speakers.

Note that this amplifier cannot drive your front and surround speakers at the same time. It is one or the other. If you do not already have a stereo amplifier, you will need to build two amplifier circuits and operate them from separate power supplies.

SWITCHED OPTION

The block diagram of Fig.1 shows how a switch may be employed so that the amplifier circuit can be used as a normal amplifier, or as a surround sound amplifier. When the switch is open the amplifier is in normal stereo mode. Hence if you do not wish to include the surround sound option, the switch and "surround extractor" can be omitted.

When the switch is closed, the "surround extractor" is selected. Note that the two ordinary left and right stereo inputs are

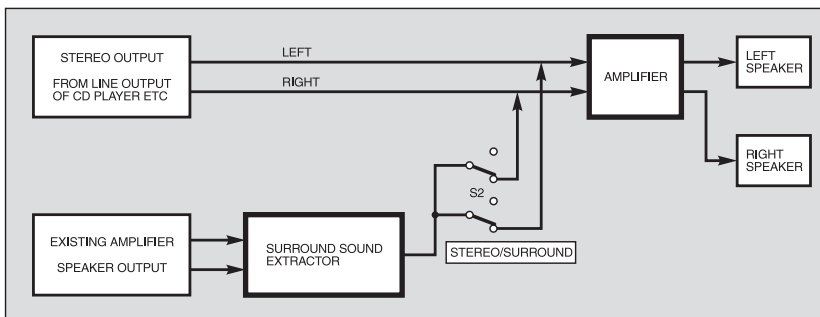


Fig.1. System block diagram for the Stereo/Surround Sound Amplifier. The heavy boxes show what is included in this circuit, plus the selection switch S2.

now joined together. So if you leave the switch in this position and use the amplifier to amplify line signals, they will be combined into a mono signal.

If you only require this circuit as a surround extractor, the switch can be omitted and the connections permanently wired as discussed later.

SUMMING UP

When the switch is open (or omitted) the circuit behaves as an ordinary stereo amplifier for use with signals from the Line outputs of CD players etc. The speakers will be at the front.

When the switch is closed the circuit must be used with an additional amplifier. The additional amplifier powers the front stereo speakers, and the circuit drives the rear speakers. Both rear speakers will deliver the same "pseudo surround" sounds.

MAIN CIRCUIT

The full circuit diagram for the Stereo/Surround Sound Amplifier is shown in Fig.2. Some people enjoy the challenge of designing a transistor amplifier from first principles, but if you require a system that is inexpensive and reliable, an amplifier based on an integrated circuit (i.c.) is the best option!

The i.c. chosen for this circuit is the TDA2822M. It is particularly unfussy about layout, operates on a supply of between 3V and 15V and provides a genuine 1W r.m.s. per channel.

It only requires six capacitors and two resistors, namely C1 to C6 and R1 and R2. These provide decoupling and stability for IC1. Overall circuit decoupling is provided by electrolytic capacitor C7.



Overall volume control is provided by VR1a and VR1b. This is a stereo-ganged potentiometer so that a single control knob operates both Left and Right channels in unison.

SOUND EXTRACTOR

The Surround Sound Extractor part of the circuit is shown inset in Fig.2, and may be omitted if not required. The "positive" speaker outputs from your additional amplifier are employed. The extractor circuit draws very little current, and will not affect your existing speakers in any way.

One of the positive speaker outputs is connected to 0V in the circuit. The other positive speaker output is connected via a potential divider made from resistors R3 and R4. The potential divider attenuates (reduces) the signal and ensures that the circuit has no effect on the existing amplifier and speaker system.

The signal is now applied to capacitor C8 which removes any d.c. which may be present. The value of C8 is not critical, and although a value of 1μF is suggested,

a lower value – down to say 100nF – should be acceptable. The only effect will be to reduce the bass content in the rear speakers, but since bass is less directional this is not likely to be significant. Note that the capacitor must be non-polarised i.e. *do not use an electrolytic type*.

Do not connect anything to the negative speaker terminals of your existing amplifier (apart from your existing speakers of course).

Notice that the signal fed via C8 and switch S2 to the circuit will represent the difference between the positive output terminals of your existing front speakers. So the voice of a singer standing in the middle of the stereo field will not appear through the rear speakers. Sounds completely out

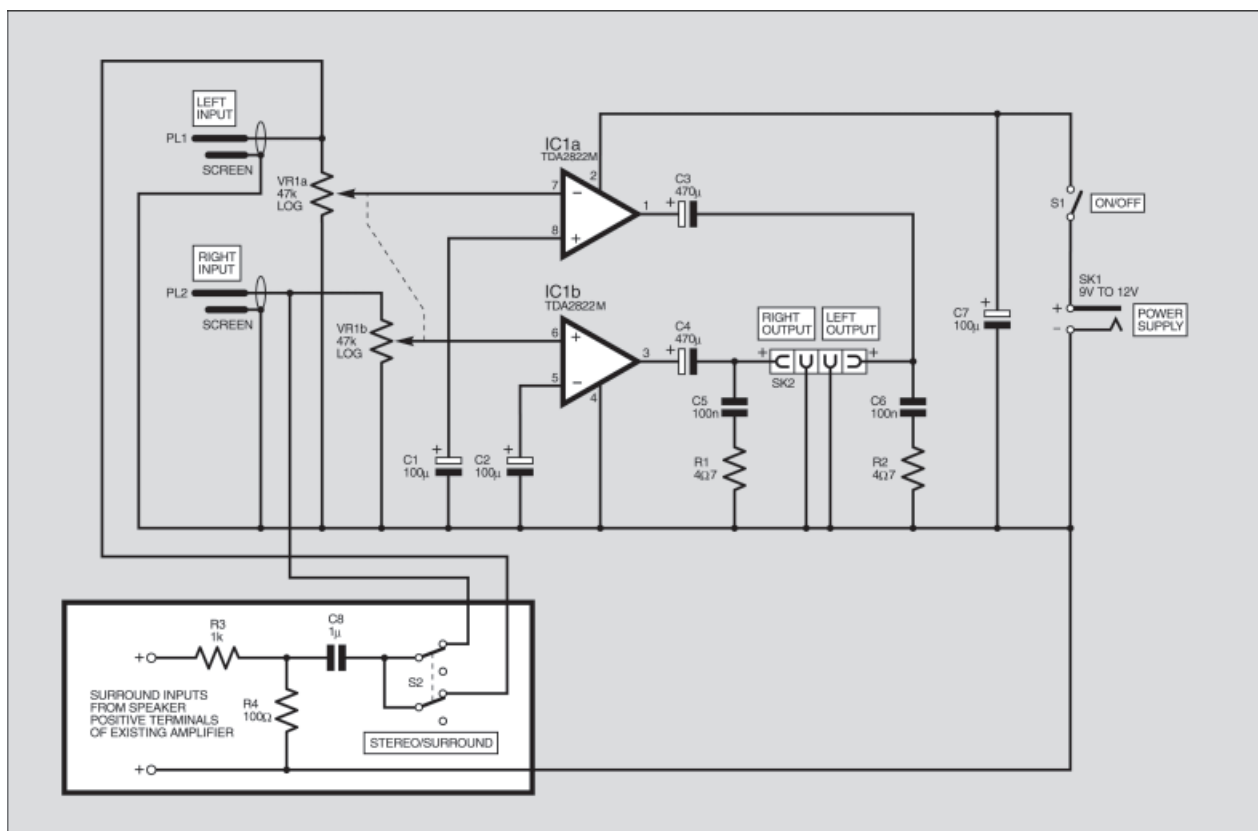


Fig.2. Complete circuit diagram for the Stereo/Surround Sound Amplifier. The surround sound extractor components are those within the boxed area. The "surround" inputs must only be taken from the speaker positive terminals.

of phase via the front speakers will be amplified and directed also through the rear speakers. This will include rear sound effects as used in modern films.

Sounds directed off centre will also appear via the rear speakers and although – strictly speaking – this is an error, in practice it should not present a problem.

OPTIONS

The printed circuit board (p.c.b.) component layout, including the “surround” components, together with a full-size underside copper foil master for the Stereo/Surround Sound Amplifier is shown in Fig.3. This board is available from the *EPE PCB Service*, code 304.

The interwiring details from the circuit board to the off-board components is also shown in Fig.3. If you only require the circuit as an ordinary stereo amplifier, then omit components R3, R4, C8 and switch S2. If you only require the circuit as a surround sound extractor, then omit switch S2 and link the connections as shown in Fig.4.

If you require both options (*remember that you cannot use both at the same time*) then fit all components and selector switch S2. This switch allows you to quickly select between using the circuit as a stereo amplifier, or as a surround extractor for the rear speakers.

CONSTRUCTION

The printed circuit board is designed to take the dual stereo Volume control VR1. Begin construction by checking that the control does fit and that the holes in the p.c.b. are large enough. If the control does not fit, or if you would prefer to use two separate controls for the Left and Right channels then a set of wires may be used to link the p.c.b. with the controls. Either way, do not solder in the control(s) at this stage.

Solder in the smallest components first, such as resistors and the 8-pin d.i.l. socket for IC1. Fit the smallest capacitors C5 and C6 (and C8 if required). These may be fitted either way round. Now fit the larger electrolytic capacitors taking care with their polarity. The negative side of each capacitor should be indicated down the side of its casing and its longer lead usually indicates positive.

Next solder in position the potentiometer (Volume control), either directly into the p.c.b. or via wires. If you have a potentiometer which will fit directly into the p.c.b., then the circuit board will not require any additional fastening when housed inside a case.

Insert terminal pins for the various “lead-off” wires. The circuit may be connected to the Line output from a CD-player etc. either directly via twin-screened cable, or via plugs and sockets as shown in Fig.3. Ensure that the screen of the cable (i.e. the wire “mesh” which surrounds the inner insulated wire) is connected to the 0V side of the circuit.

The speaker connections can be made via a speaker terminal block, SK2, as shown. Note that this is fitted from the outside of the case, so do not solder it at this stage.

If you are using the circuit to drive rear speakers you will need to link the “surround inputs” to the *positive* speaker terminals of your *existing* amplifier. This can be achieved with ordinary wires.

Completed p.c.b. showing the

stereo pot. mounted on the board.

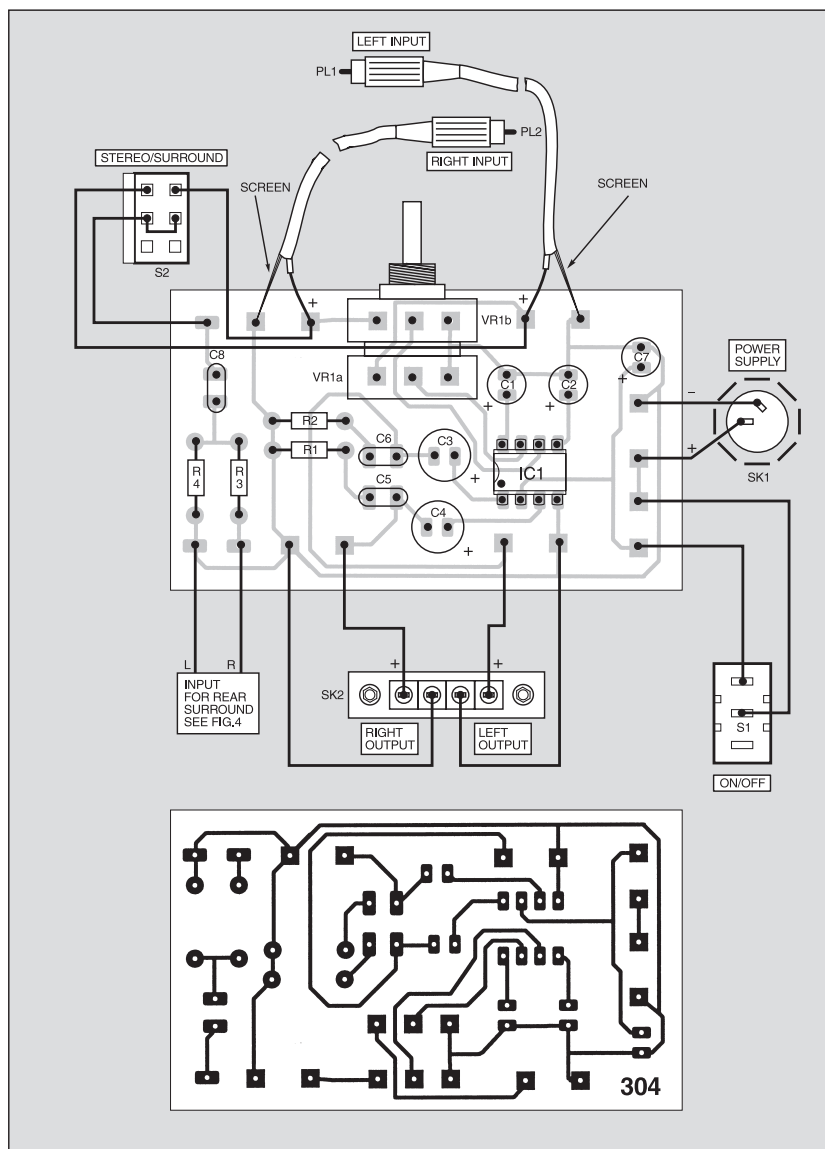
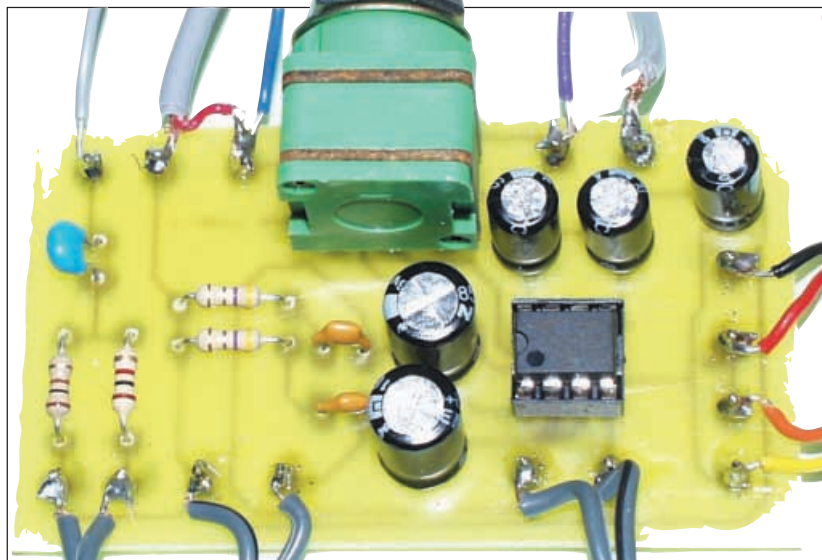
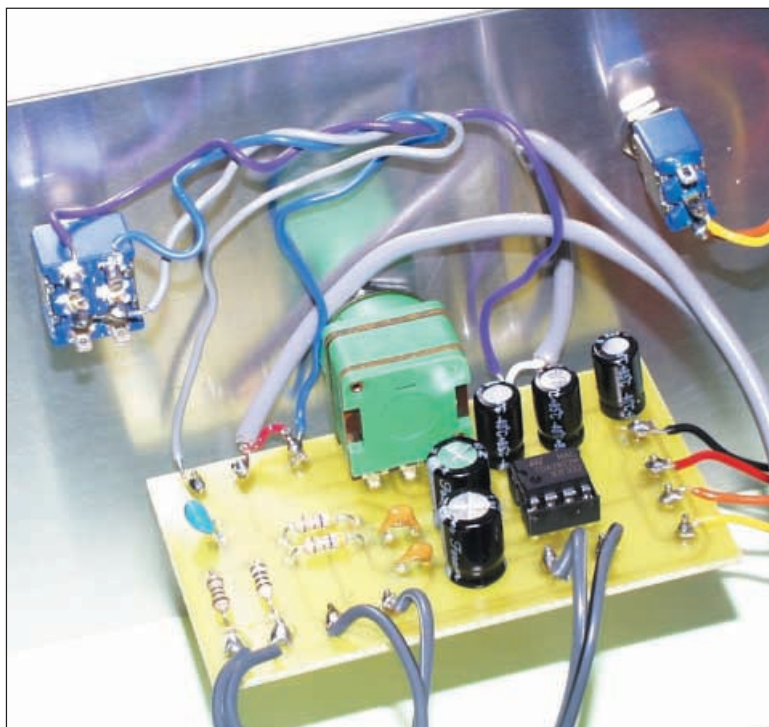
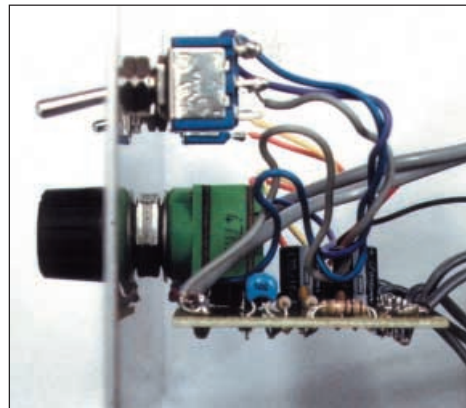


Fig.3. Amplifier printed circuit board topside component layout, wiring and full size copper foil master pattern.



*It may not be Dolby Pro-Logic
but the effect – considering
the modest cost – is quite
convincing.*



The circuit board is held in position on the front panel by the dual-ganged potentiometer mounting bush and nuts.

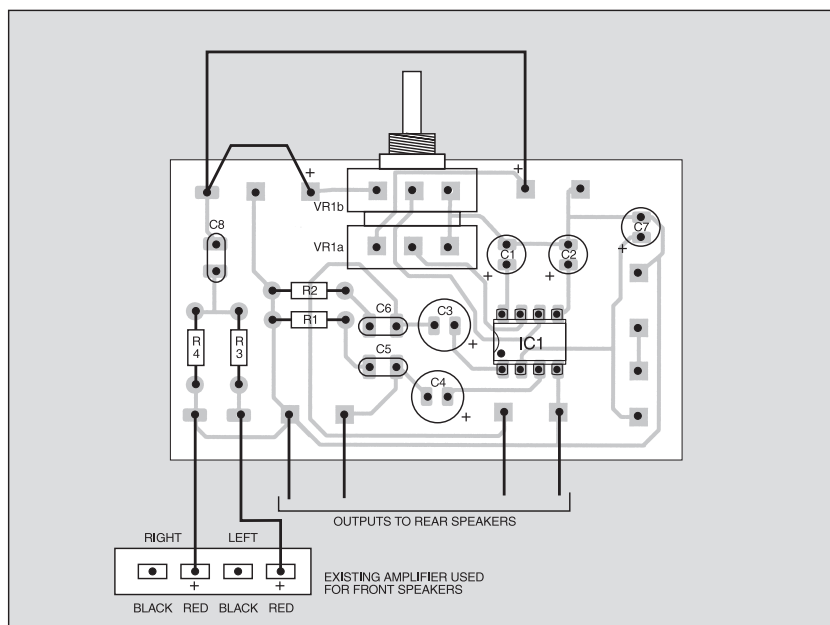


Fig.4. Amplifier used as a surround sound extractor and to drive the rear speakers. Switch S2 is omitted and link wires inserted as shown.

TESTING

Connect some loudspeakers (4 ohm to 8 ohm are ideal) to the amplifier. (Note that – unlike some amplifier designs – it does not matter if a speaker output is left open circuit i.e. not connected).

Stereo

Set switch S2 (if used) to Stereo. Power up the circuit and apply a test signal from a "Walkman" etc. A Line output is ideal, though a headphone output will work if no alternative is available.

Check that all is well and that the two stereo channels are separate. Test this by disconnecting one of the stereo line inputs. The appropriate speaker should go silent. If

both speakers continue working, it is likely that the left and right channels are joined somewhere. For example, you may have switch S2 set wrongly.

Surround

Set switch S2 to the Surround position and connect the Surround Inputs to the Red (+) connectors of the Left and Right speakers of your existing amplifier.

Try to test with a recording from a film soundtrack or solo artist. You should notice that sounds (such as dialogue) from the centre of the front stereo field are hardly audible via the rear speakers. But sounds off centre are amplified more, and effects sounds are amplified the most.

COMPONENTS

Resistors

R1, R2 4 Ω 7 (2 off)
R3 1k
R4 100 Ω
All 0.25W 5% carbon film

Potentiometer

VR1 47k dual-ganged (stereo)
rotary carbon, p.c.b.
mounting, log.

Capacitors

C1, C2
C7 100 μ radial elect. 16V
(3 off)
C3, C4 470 μ radial elect. 16V
(2 off)
C5, C6 100n ceramic (2 off)
C8 1 μ any non-electrolytic
type, such as polylayer

Semiconductors

IC1 TDA2822M 1W stereo amp.

Miscellaneous

S1 on/off toggle switch
S2 d.p.d.t. toggle switch
SK1 2.5mm d.c. power socket,
chassis mounting
SK2 4-way, spring-loaded,
loudspeaker connector
block
PL1, PL2 phono plug (2 off)

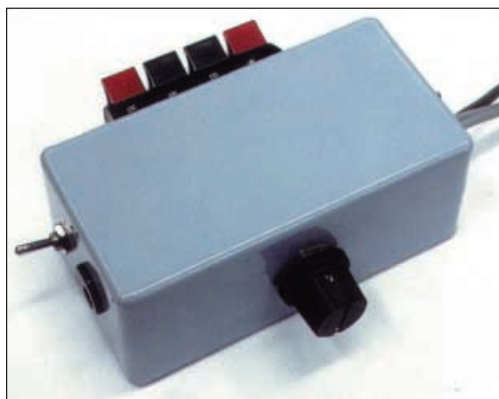
Printed circuit board available from the
EPE PCB Service, code 304; sloping
front case, size 160mm x 100mm x
60mm; 8-pin d.i.l. socket; plastic knob; 9V
to 12V battery or regulated mains power
supply adaptor (300mA or more);
screened cable; multistrand connecting
wire; solder pins (15 off); solder etc.

Approx. Cost
Guidance Only
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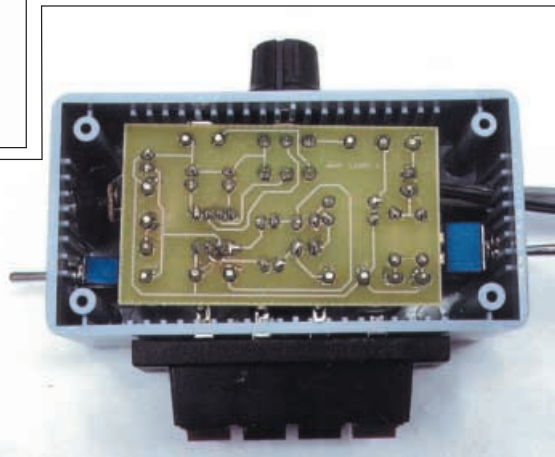
£15



Completed amplifier housed in a sloping-front case and showing the power input socket and the spring-loaded loud-speaker connecting blocks.



(Above right)
Completed
amplifier housed
in a standard
plastic case.



(Right) The circuit
board is a neat fit
in a standard
plastic case.

BOXING UP

The prototype unit was housed in a sloping front case measuring approximately 16cm by 10cm and 6cm deep at its highest point. The front panel layout and general positioning of components within the case can be seen in the photographs. The photographs also show how the p.c.b. may be housed in a standard case.

You may wish to use a similar case and front panel layout as shown, in which case you can make up a "dummy" front panel from stiff cardboard (it's easier to cut, drill and modify) to check that the front panel components will fit into the case without clashing with any other side-mounted components. Using the card as a template, place it over the front panel of the case and drill the 3 holes for the switches and potentiometer. (This assumes that you require all the options as described earlier).

Drill suitable holes in the sides of the case for the speaker connector (SK2), power input connector (SK1) and audio input wires. Alternatively you could use connectors for the audio input, in which case drill the appropriate holes for the connectors.

Once you have drilled out the front panel, you can letter it, possibly using "rub-down" transfers, or you can make up a second thin

card "overlay" with lettering on it. This can be positioned on the panel, the required holes punched in the card and the switches and potentiometer bolted in place.

Now complete the final wiring from the p.c.b. to the speaker connector and power socket. Ensure that the polarity of the power supply correctly matches the power socket and conduct a final test of the amplifier. ☐

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7/01

PC USERS CAN HELP MEDICAL RESEARCH

Anyone with a fast PC can use it to analyse medical research data and help discover potential new drugs. Barry Fox reports

FOR most of the time, most PCs are idling. Either they are doing no work at all, or only a fraction of the processor power is being used by wordprocessor, E-mail or database software.

The idea of exploiting this spare capacity dates back at least three years, when SETI, the Search for Extra-Terrestrial Intelligence (once funded by the US Government but now a cash-strapped voluntary League) started using idle computers and obsolete satellite systems to look for recognisable patterns in radio signals received from space. A regular pattern could signify distant intelligence.

Peer-to-peer analysis

United Devices of Austin, Texas, has now joined with chipmaker Intel and the National Foundation for Cancer Research and Department of Chemistry at Oxford University, to use "peer-to-peer" computing for analysing the characteristics of possible new drugs. The challenge is to check hundreds of millions of molecular structures for their ability to match and block the proteins which are critical to the growth of cancers, such as leukaemia.

This is obviously a "good cause" and anyone with a PC can go to www.intel.com/cure or www.ud.com/home.htm and download a computer program which downloads possible drug structures and runs jigsaw-match checks on them.

The PC runs the program in the background, when it would otherwise be idle – rather like a screen saver. Once the jigsaw check is complete, which should normally take a day or so, the program sends the results back to United Devices Data Centre and requests a new package of data to check. This happens automatically when the user goes onto the Internet to look at any other site.

Virtual supercomputer

Intel predicts that worldwide downloads will eventually involve millions of participants and generate a virtual supercomputer which is ten times more powerful than any of the world's existing super computers.

Because large projects are broken down into smaller tasks, the proprietary drug information should remain secure. Hopefully the involvement of Intel guarantees security against viruses. But does the program slow down a PC by soaking up processing power? No, assures Daven Oswalt of Intel.

"When applications are being used, these peer-to-peer programs stay on the sidelines, so as not to interfere at all with the user's main application processing. It is only at moments when a user is not engaged in processing that the peer-to-peer program computes. This could be when a user steps away to do something else, but leaves the PC on, or when he or she is at the computer but momentarily not using any processing power – not inputting anything that requires a response from the computer, for example.

"Having a more powerful PC not only means faster user application processing, but also faster processing of any peer-to-peer applications that are resident on the PC, such as any philanthropic peer-to-peer program."

United Devices also assures: "The UD Agent will never interfere with your ability to use your own computer. Most computers never use all their resources – it is estimated that up to 90 per cent of the processing power of an individual PC goes unused. The United Devices distributed computing model is based on the ability to utilize this *idle* capacity from individual computers."

But poorly documented

There is no reason to doubt these assurances, but the program is very poorly explained. Users only find out by trial, error and exploration that there are options to tweak the way the program runs, for instance displaying graphics which show the molecules being checked.

The program does not explain what it is doing on the Internet and why it sometimes tries to force a connection and cost the PC owner money on-line while uploading results and downloading more data. This can be very disconcerting for casual users who are worried about viruses. Also, only the highest speed Pentium PCs will be able to plough through the millions of calculations in a reasonable time. Slower PCs will still be at a few per cent of the task after days.

There is no information offered on how to get rid of the agent, but this can be done with the usual Windows Settings, Add and Remove Programs options.

If Intel, United Devices and Oxford University want people to volunteer their resources they should surely pay them the courtesy of offering a better explanation of what the UD Agent software is doing while it lives inside a PC.

UNIVERSAL PROGRAMMER



The LabTool-48 is an "intelligent" universal device programmer which works through your PC's parallel port. It features a 48-pin universal pin driver and an expandable TTL pin driver and supports over 3000 different devices, including memory, logic and single-chip. It can handle *all* of Microchip's PIC series. The literature received states "no adaptor required for any DIL device up to 48 pins – guaranteed".

Device types catered for are PROM, EPROM, EEPROM, Flash, Serial PROM, NVRAM, PAL, GAL, CEPAL, PEEL, CPLD, EPLD, OTP and Flash microcontrollers. Operations include read, blank check, device insertion/contact check, verify, checksum, EEPROM ID check, compare, erase chip, function test, program, memory protect, device configuration setting, device search, edit buffer, mass production mode, modify vector, serialization, H/L byte buffer swap, buffer search.

For more information contact Burn Technology Ltd., Dept EPE, Winfrith Technology Centre, Building C51, Dorchester, Dorset DT2 8DH. Tel: 01305 852090. Fax: 01305 851940. E-mail: sales@burntec.com. Web: www.burntec.com.

PICS ON-SCREEN WEBSITE

SIMON Blake of the BlackBoxCamera Company wants you to know about his company's website and their new product, the PIC16F84-STV5730A On Screen Display (OSD) project board.

He tells us the STV5730A is an OSD i.e. widely used in VCRs for displaying on-screen programming menus. Combining this device with a 16F84 gives it the ability to display text and graphics characters on any TV or video monitor. The product provides the hardware and software to create both simple and complex OSD applications, and the website provides free development resources.

For more information contact The BlackBoxCamera Co. Ltd., Dept EPE, Unit U7, Lenton Boulevard, Nottingham NG7 2BY. Tel/Fax: 0700 2522526. E-mail: Simon.Blake@STV5730A.co.uk. Web: www.STV5730A.co.uk.

Greenweld's Bargains

BY the time you read this Greenweld's new 32-page May catalogue should have been published. We know that as usual it will have a good selection of the bargains for which Greenweld are renowned (*Greenweld – Home of Bargains* is the slogan on their last newsletter received).

Greenweld's bargain lists are well-worth obtaining – ask for your copy now! Greenweld Ltd., Dept EPE, PO Box 144, Hoddesdon EN11 0ZG. Tel: 01277 811042. Fax: 01277 812 419.

E-mail: bargains@greenweld.co.uk.

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Voice of the Crystal

QUITE likely many of you will consider Crystal Radio to be an almost forgotten stepping stone on our tortuous route to achieving today's electronics technology. It is, though, a technology that can still be experimented with and rewarding results achieved.

To emphasise the point, we were recently sent a rather delightful book written and illustrated by H. Peter Friedrichs, called *The Voice of the Crystal*. Peter comments that while his book fits into the genre of crystal radio, it goes beyond that and "it's quite unlike any you've seen before". It introduces radio theory in simple layman's terms and then proceeds to demonstrate how to build various radio components completely from scratch. The various components are then linked together to create working radios.

Construction covers building fixed and variable capacitors, a variety of coils including slider, spider and basket-weave types, a plethora of detectors using a veritable rainbow of materials. The book also describes the construction of three different types of home-build headphones, including a piezoelectric design fashioned from the components of a cigarette lighter!

This 185-page book is published in the USA but is readily purchasable online from www.amazon.com, who quote a price of US \$14.95. No doubt your local good bookseller could also obtain a copy for you, ISBN 0-9671905-0-9.

NATIONAL VALVE MUSEUM



Allan Wyatt of the National Valve Museum has sent us the Museum's remarkable CD-ROM, which contains photographic images and details of many of the world's early valves.

Allan tells us that the museum was founded early in 2000 with the specific aim of providing a first class digital collection of this essential part of our national heritage. The original plans for digital collections were discussed with major museums which, while they completely supported the initiative, had no funding available to do something similar or to help.

The window of opportunity seemed too small to let it drop, so Allan has funded it himself. The core of the project is a publication database with high quality digital pictures, accessed via the Internet or via CD-ROM.

Each indexed term is validated against a master list to maintain accuracy. All of the web pages and indexes are generated from a batch process to make updates fast and easy and the equivalents list is dynamically linked to the exhibit entries each time the process is run.

All software from the database onwards has been designed specifically for the museum project. A physical home is not practical at present, and Allan feels that a close-up picture can convey far more than a cabinet full of valves.

The Museum regularly receives 2,500+ visits to its web site per week.

For more information contact The National Valve Museum, Dept EPE, 75 Millbrook Road, Crowborough, East Sussex TN62SB. Web: www.valve-museum.org

Stamplets to Cure the Spam Deluge?

Barry Fox reports on a proposal for reducing unwanted E-mail messages.

ANYONE who uses E-mail is cursed by spam – unwanted messages that buck-et through from the Internet, offering "100% FREE" opportunities to spend money on becoming a millionaire.

Although subscribers to reputable E-mail services who send spam can in theory be stopped, most unsolicited junk E-mail now comes from anonymous senders using untouchable services in far-off lands. China is a prime suspect.

CD-ROMs, costing a few dollars, contain literally millions of E-mail addresses, and can be used to automate E-mail transmission. It takes only four hours to send a million spam E-mails and it costs the sender only an hour in line time.

Filtering Spam

Some Internet service providers now try and filter mail by searching for tell-tale words. But the spammers then avoid those words. Others use the Brightmail system which uses trap accounts to attract spam and then put a network block on everything from the same address or with the same header. But spammers can then change the headers and sender addresses.

Guernsey-based Anodyne Developments thinks it has a better solution, with Stamplets. The E-mail or Internet service provider installs software which interrogates the address list stored in the Internet mail software (e.g. Microsoft Outlook or Netscape Messenger) on the user's PC. It then lets through only those messages which come from known addresses.

All other messages, which may either be unwanted spam, or wanted messages from unknown or new senders, is then held for up to 30 days on the service provider's server. An automated reply is transmitted to the sender, saying that the original message will only be delivered if the sender pays a small fee. This is payable in any of the online

credit and debit micro-units used for e-commerce and Internet auctioning. These units are for instance tied to the price of gold, with credit bought in advance at the beginning of each month by credit card.

Anodyne's Stamplets system would let E-mail users give out free credit to people charged for sending wanted E-mails, and set their own price to charge spam senders.

Deterrence

If adopted, the system would certainly deter anyone sending unsolicited messages by the million, because they would face heavy bills to get their messages through. But first the E-mail and Internet service providers must adopt the system and so far there have been no big-name takers. Also some users may not like the idea of wanted E-mails from unknown senders initially being blocked.

MARCONI MUSEUM

The interactive online Marconi Museum has been opened by E-minister Patricia Hewitt. The website coincides with the 100-year anniversary of the world's first transatlantic wireless transmission by Guglielmo Marconi, the pioneer of wireless communication, and captures his extraordinary achievements.

The website features 10,000 web pages containing an historic collection of 500 pieces of ephemera, 426 photographs, 33 sound clips and 10 film clips. The Marconi Online Museum caters for interests of all ages, including students, historians, researchers and wireless enthusiasts, and particularly school children, for whom the content is directly relevant to the National Curriculum.

Visit www.marconicalling.com.

New Technology Update

Non-volatile memory based on CD-ROM technology promises smaller, faster devices with a multitude of applications, reports Ian Poole.

IN today's electronics technology, memory is being used in increasing quantities. PCs usually have a hundred or more megabytes of RAM, whereas only ten or fifteen years ago a few kilobytes was standard. This increase has become necessary due to the development and use of far more sophisticated computer software. However, technology has had to advance to enable memory to be sufficiently compact and cheap to be used in this way. It is often said that memory is cheap and this is quite true. It only costs a few tens of pounds to put more memory in a PC.

To meet the ever-growing requirements for memory, new technologies are being developed. In one development ST Microelectronics is to start work on a joint development project with the US based company, Ovonyx. The aim is to build non-volatile memory based around the techniques used in rewritable CDs.

The new memory is named phase change or amorphous memory and the basic technology has been developed by Ovonyx, a company that has come out of Energy Conversion Devices Inc. The memory is based on an alloy that can be converted from an amorphous to a crystalline state and back again by using an electric current. The two phases or states of the material have quite different resistances enabling it to be used to store information.

ST have obtained a licence from Ovonyx that will let them build this memory technology into microcontrollers, system-on-chip, and bulk memory devices as well as reconfigurable logic devices.

Technology

The technology uses unique thin film materials to store information in a very compact manner. The memory is based around a phase change chalcogenide alloy similar to that used to store information on commercial rewritable CDs and DVD RAM.

Optical disks use light from a laser to convert small spots on the disk from the amorphous state with a disordered structure to a crystalline state with a regular atomic structure. In this way the digital data can be stored because the amorphous state is non-reflective and has a high resistance whereas the crystalline state is reflective and has a low resistance.

The phase change memory operates in a very similar manner but uses an electric current to change the state of the material. To read the data, a voltage is applied to the storage area and the state of the cell is detected by the amount of current that flows. The system is particularly efficient and can store data in a much smaller area

than its optical counterpart. Furthermore, data can be read and written at a much greater speed and there are cost advantages over more conventional forms of memory, including DRAM and Flash. This results from the very small active storage area and the simple manufacturing process required. In fact the manufacturing process deviates only a little from the standard CMOS flow line, making it very attractive for manufacturers who would not have to invest large sums in new plant.

Basic concept

The material that has been most widely used in amorphous semiconductor memories to date has been a composition based on germanium and tellurium (GeTe). Small quantities of other dopants such as antimony can be added to improve the conductivity for the low resistance phase. In addition to this selenium is often added to improve the switching performance.

The crucial aspect of the device is in switching the memory element between the high and low resistance states. In fact both conversions are implemented by heating the data storage element itself with a high current pulse. The current pulse is sufficient to melt the storage element and on cooling down it crystallises so that the atomic structure is ordered and the material can conduct an electric current through a low resistance.

To reverse the change and erase the data a higher current pulse is applied. Typically this will be about ten times that of the original write pulse and will have much faster rise and fall times. The effect of this is that when the molten material cools down it changes to its amorphous state with a high resistance.

Device structure

Details of the actual device structures in use at the moment are not very clear as little information has been released. One structure that may be in use is shown in Fig.1. Here the data storage region is filled with the chalcogenide. When in the crystalline state current can flow from the

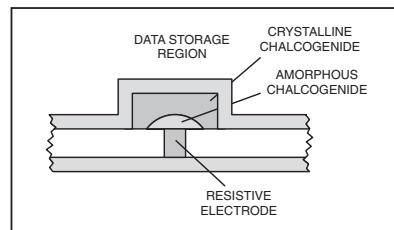


Fig.1. Planar form of an amorphous memory

upper electrode to the resistive element. Obviously when in the amorphous state it will exhibit a high resistance and significant current will not be able to flow.

Performance

The memory has many advantages. It is non-volatile allowing the information to be retained even when the power is removed. Currently Flash is the most widely used form of non-volatile memory. This has the disadvantage that it has to be erased in blocks. In addition to this the memory only has a limited number of read/write cycles. Today's devices typically withstand about 100,000 write cycles.

Amorphous memory does not suffer from either of these problems, having a virtually unlimited lifetime and each cell can be individually addressed for both read and write. This enables it to be used in ordinary memory applications as well as those that would normally have been serviced by Flash memory.

A further advantage is that no power is required to maintain the memory even when in standby "operation". Other forms of memory use considerable amounts of current and as a result this will give amorphous memory a significant advantage, especially for portable applications where battery size and lifetime are primary considerations.

Future

The small size, flat topology and the low voltage operation make the memory very suitable for migration to smaller geometries than those that are being used today. In fact the performance of individual cells improves if they are scaled down in size. Interestingly, the reverse is true for memories such as Flash where the amount of charge stored is dependent upon the surface area of the electrodes within the cell. If the amount of charge stored is too small then the performance of the memory will be impaired.

The advantages of amorphous memory mean that it should find uses in a wide variety of applications. Laptop and palmtop computers will be a particularly suited. In addition to this the new multimedia third generation mobile phones will have a far greater requirement for memory and they should find many uses in this arena. Apart from the portable applications where their low power consumption is of particular interest they should find widespread use in virtually all types of electronics where memory is required. Obviously this will include the run of the mill computer applications where there is a truly vast market.



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If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC based oscilloscope could be yours. Every six months, Pico Technology will be awarding an ADC200-50 digital storage oscilloscope for the best *IU* submission. In addition, two single channel ADC-40s will be presented to the runners-up.

Zener Diode Tester – Service Check

HAVING amassed a large collection of surplus Zener diodes, some using type numbers and codes which are obsolete, others having lost their markings altogether, the circuit diagram shown in Fig. 1 was developed to check their polarity and voltage. It supplies a constant current to the device under test and a digital voltmeter (DVM) then reads the Zener "breakdown voltage" across the device. The constant current source ensures the Zener is unlikely to be damaged.

In the circuit, transistor TR2 forms a constant current source in conjunction with diodes D1, D2 and resistors R1 and R2, to provide a test current of approximately 7mA into TR2's collector. With no test diode connected, the meter reads the supply voltage, either 33V or 6V depending on which positive test terminal is used. This indicates the off-load battery voltage.

When the test diode is connected current flows through it to 0V via resistor R3.

Transistor TR2 is turned off at this time as its base current, via resistor R1, is blocked by TR1. Provided current through the test diode exceeds about 7µA then the voltage developed across R3 is sufficient to turn on transistor TR3.

The base current of transistor TR3 is limited by resistor R5 to a safe level under all conditions, and capacitor C1 decouples TR3 base. The transistor's collector current is drawn from the +33V supply via transistor TR1's base emitter junction, turning TR1 on. Resistor R4 prevents TR1 being spuriously turned on by any leakage in TR3 whilst capacitor C2 decouples TR1 base.

With transistor TR1 turned on, this provides the base current for TR2 via R1, enabling the constant current source to be used for measuring the test diode's Zener voltage. As soon as the test diode is removed the circuit returns to its quiescent state. If the polarity of the device is unknown, connecting

it the wrong way round will give a reading of 0.6V to 0.7V on the DVM as a Zener behaves like an ordinary silicon diode in the forward direction. Should the device be a short-circuit then 0V will be read on the DVM.

Devices other than Zener diodes could be checked by the circuit. By using three 9V PP3 type batteries (B1 to B3) in series with four "AA" cells (B4 to B7) as shown, i.e.d.s. could be safely checked for operation and polarity. Note that using the 6V tap for testing will not risk reverse breakdown (usually quoted as 5.1V for an i.e.d.) if the device is accidentally reversed when testing. If the i.e.d. is serviceable and correctly polarised the 7mA test current gives a visible light.

This principle could be extended to safely sorting the pinouts of unknown 7-segment displays.

J.A. Morton,
Sowerby Bridge, W. Yorks.

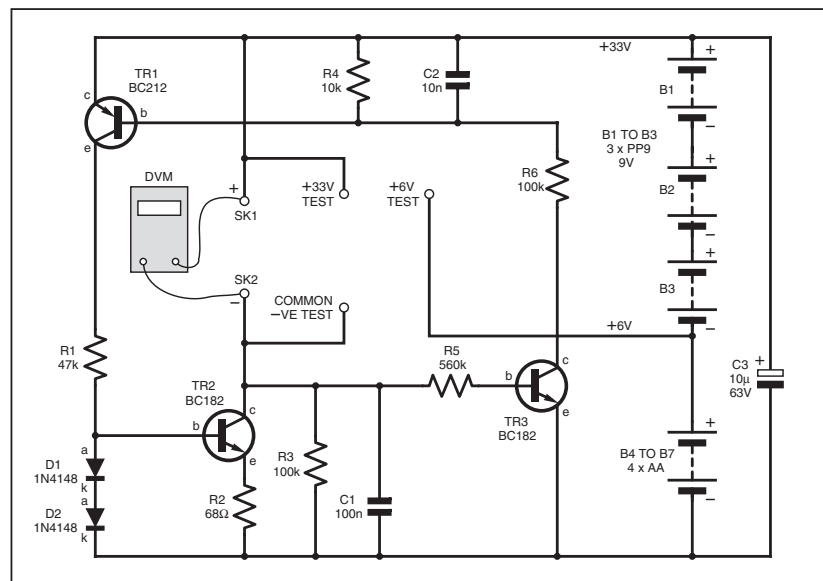


Fig.1. Circuit diagram for a simple Zener Diode Tester. Note that capacitors C1 and C2 are disc ceramic types.

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Cupboard Door Monitor – Shut That Door

THE circuit diagram of Fig.2 emits a beep (more like a wail) every time a cupboard (closet) door is opened. It sounds somewhat like a cat's "miaow" – which is an ideal warning noise for a cat-hater (*You beast! Ed*)!

The circuit is very simple, and is based on a CMOS 4069 hex-inverter chip, IC1. Gates IC1a and IC1b form an oscillator at about 700Hz, which is buffered by gates IC1c to IC1e. Gate IC1f is unused, so pin 1 is tied to the positive supply to prevent it from floating.

Microswitch S1 is mounted on the cupboard such that it changes over whenever the door is opened. When it does so, capacitor C3 charges up from battery B1, thus powering the circuit for about five seconds.

As C3 charges and the voltage across it rises, the voltage left to the rest of the circuit falls, so generating a falling, diminishing tone. The capacitor is discharged when the door is closed; resistor R3 protecting the switch contacts from damage caused by the charge accumulated on C3.

The piezo disc X1 is driven with two signals of opposite polarity in order to double the amplitude of the signal, so making it louder. If the piezo disc is mounted rigidly on the wood of a cupboard, this acts like a resonator which will amplify the tone.

Battery life is excellent, as the circuit only consumes power when it is actually sounding. If the door is left either closed, or open, no appreciable current flows.

Richard Neill,
Cookham Dean, Berks.

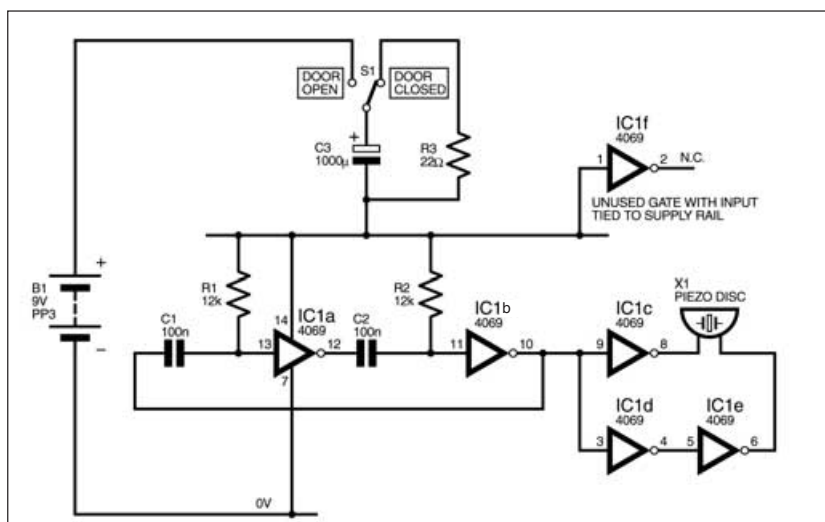


Fig.2. Circuit diagram for the Cupboard Door Monitor.

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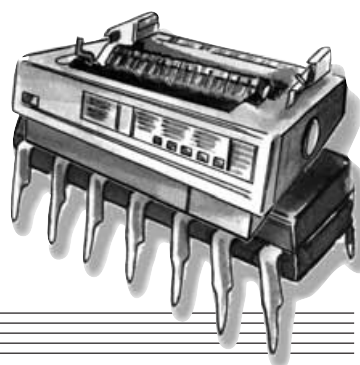
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PIC TO PRINTER INTERFACE

JOHN BECKER



Demonstrates PIC control of Epson dot-matrix printers, and offers a long-term hard-copy data logger.

EPE reader Andy Daw had a letter published in *Readout* March '01. To precis it, he said:

I read with interest the UFO Detector/Recorder in the January '01 issue. The ingenuity of Raymond Haigh's chart recorder is inspiring. Having once refurbished a chart recorder for recording auroras I know that hard copy recording of analogue events is hard work. What is needed is a cheap and easy method.

Some people have bought new colour printers and their old dot matrix printers are just sitting in the loft. It would be nice for EPE to do a PIC-based analogue interface to dot-matrix printers – Z-fold paper for week-long recording, A4 for shorter periods, variable "chart" speed, date stamp and grid lines.

What a good idea it seemed! And described here is one way of doing it. In fact, it is not at all difficult.

EPSON PRINTERS

A good ten years ago the author investigated Epson printers and how they could be instructed, through GW-Basic and QuickBasic, to print graphics data recorded in connection with a weather centre and other DOS-based designs. Those designs basically output data to the PC's screen and to disk, but the facility to also output screen displays to a printer was deemed to be worthwhile.

Consequently, the author obtained Epson's ESC/P reference manual, a massive tome that details how all the functions of Epson's printers can be controlled. Through it, the desired graphics printout facilities were added (long before the days of Screen Dumps through Windows!).

The introduction to the manual says that:

When Epson created the ESC/P printer control language, the industry standard for sophisticated, efficient operation of dot matrix printers was born.

To ensure that the features on all Epson printers are used to their fullest, this reference manual was created as an aid in

creating programs and drivers. In addition, information is included on features and options available on all dot-matrix printers produced by Epson for the American, European and non-Japanese Pacific markets.

The manual is applicable to the full Epson range, including ESC/P2 and ESC/P 24-pin printers, and ESC/P 9-pin printers. The latest version, actually dated December 1997, was downloaded free from Epson's web site by the author in February 2001 (see later).

It is to this edition that certain page references are made within this article. The commands used are those which the manual states are backwards compatible with all ESC/P and ESC/P2 models.

Consequently, it would appear that the interface described here can be used with *any* Epson-compatible dot-matrix printer. As the author has proved, the manual's data is applicable to *some* inkjet colour printers as well. It has been proved with the dot-matrix LQ-550 and LQ-570 and with the inkjet Photo 600 and Stylus Photo 750. A third inkjet printer, though, a Photo 650 purchased in Feb '01, would not respond to the graphics commands from the experimental board, although it did respond to the text commands.

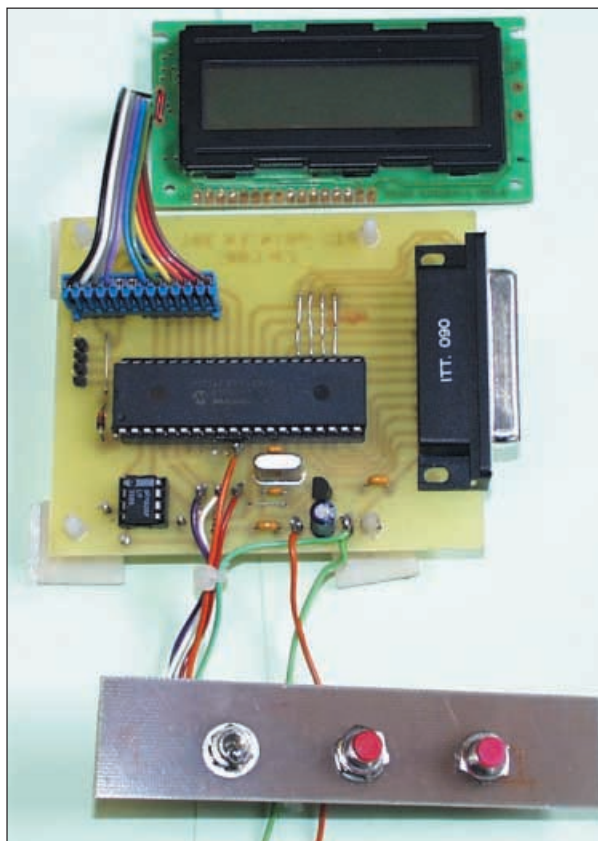
However, the "brief" of this design, as set by Andy Daw,

was to show how dot-matrix printers could be controlled. The fact that it can control some inkjets is therefore a bonus!

It is only the simplest of commands that are demonstrated here, showing how text and graphics can be printed under PIC control. The information presented, though, should allow readers to add their own additional printing features according to Epson's commands as listed in their manual, including text font selection (lettering size and style) and enhanced graphics printing.

COMING NEXT

This article first examines how Epson printers are controlled, and then as a practical example, describes the construction of a simple data logger. The logger inputs analogue data having a level between 0V and +5V d.c., converts



Test model that interfaces an external d.c. signal source to a PIC microcontroller which prints it as a graph to an Epson dot-matrix printer.

it to digital and then plots it as a graph on the printer.

The logger has pushbutton-selectable sampling periods, ranging from once per second to once every 255 seconds (4¼ minutes). Data is plotted from the top of the paper downwards, allowing Z-fold (fan-fold) or cut-sheet paper (e.g. A4) to be used.

An hours-minutes-seconds clock facility is built into the controlling software. It starts at zero when sampling is started and the elapsed time is printed to paper after every eight samples. Signal amplitude graph lines (rule lines) are plotted at zero, ¼, ½, ¾ and maximum amplitude intervals.

A non-inverting unity-gain d.c.-coupled op.amp is included on the printed circuit board. It is left to users to add signal amplification or attenuation stages of their own design. These must provide a d.c. output voltage lying between 0V and +5V. Since sampling is intentionally at very slow rates, a.c. coupling of signals seems impractical.

Readers are encouraged to modify the basic PIC software to suit their own needs in other designs. To repeat an earlier statement, the design described here should be regarded as a demonstration of PIC to printer interfacing, but which also has a practical application.

PRINTER TIMINGS

The simplest function that can be performed on a printer is that of printing text, taking advantage of the printer's own character generators. The operation is to output each text character as its ASCII value (the Data), and pulse the printer's Strobe line down and then up. When all characters have been output for a given text line, a "carriage return" command is sent, followed by a "line feed" command.

The order of operations for a single data item is shown in Fig.1.

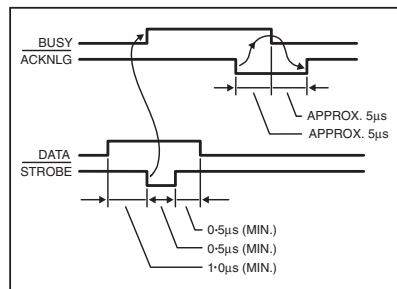


Fig.1. Typical Epson dot-matrix printer control waveforms.

It will be seen in Fig.1 that as well as Data and Strobe, there are two other control waveforms, those for the Busy and Acknowledge lines. The Busy line goes from low (logic 0) to high (logic 1) when the Strobe line goes low. It returns low shortly after the Strobe line returns high. Busy must always return low before the next command is sent.

As shown, there are minimum timing and signal order requirements for the Data, Strobe and Busy lines. The values given in Fig.1 are the "worst case" values quoted in Epson's data; some printers respond more quickly than is indicated. However, it is probably best if you regard the longer

LISTING 1. Send text to printer directly via parallel printer port

```

PORT = &H378:                                ' or &H278 or &H3BC – basic Port address
OUTDATA = PORT:                              ' Data output register (e.g. H378)
INDATA = PORT + 1:                           ' Data input register (e.g. H379)
CTLDATA = PORT + 2:                         ' Control data register (e.g. H37A)
OUT CTLDATA, 254:                            ' binary 11111110 – i.e. bit 0 (Strobe) = 0
A$ = "This is a printer test line":          ' line to be sent to printer
FOR A = 1 TO LEN(A$):                        ' for length of the test line (A$)
D = ASC(MID$(A$, A, 1)):                     ' get ASCII value of each character in turn
GOSUB PRINTDATA:                             ' send the value to the printer
NEXT:                                         ' repeat until all done
D = 13:                                       ' send carriage return (ASCII 13) to printer
GOSUB PRINTDATA
D = 10:                                       ' send line feed command (ASCII 10) to printer
GOSUB PRINTDATA
STOP:                                         ' end of routine

PRINTDATA:                                   ' sub-routine in which data is sent to printer
B = INP(INDATA) AND 128                     ' read status of Busy line (bit 7)
IF B = 0 THEN GOTO PRINTDATA:               ' wait until bit 7 goes high (= 128)
OUT OUTDATA, D:                             ' send data to printer
OUT CTLDATA, 255:                           ' binary 11111111 – i.e. bit 0 (Strobe) = 1
OUT CTLDATA, 254:                           ' binary 11111110 – i.e. bit 0 (Strobe) = 0
RETURN:                                     ' exit sub-routine

```

timings as the minimum required. That is, send Data, wait 1.0µs, take Strobe low for 0.5µs, wait a further 0.5µs, and then poll the Busy line until it is found to have returned low, after which the next command can be sent.

In simple printing operations the fourth line, Acknowledge, can be ignored. Its timing values are shown for the sake of completeness. However, as will be seen, it can be used to determine whether the printer is switched on and if its cable is connected.

BASIC DEMONSTRATION

It is easiest, perhaps, to demonstrate the operation of sending text to the printer simply by directly accessing the parallel printer port from the QBasic/QuickBASIC program in Listing 1.

If you have one of these two Basic dialects on your PC, it is suggested that you experiment with the routines in Listing 1 before you spend money on purchasing components for the PIC to Printer Interface, to prove that your printer can be controlled as discussed.

In Listing 1, the first command, PORT = &H378, sets the printer port register address. Register H378 (hex 378) is the one normally encountered on most PCs, but, as regularly highlighted by Robert Penfold in his *Interface* articles, addresses H278 and H3BC may be required by some PCs. If yours does not respond with H378, substitute one of the other addresses as the PORT value until you find which one your machine is set for.

You can also establish the Port register via Windows (95/98), using the path:

My Computer/Control Panel/System/Device Manager/Ports.

The PORT address (at H378, for instance) is the address of the register used to output data to the parallel printer port, which is named as OUTDATA in Listing 1.

Handshaking and other return lines from the printer port are input to the second register address, which is the next

address up from the first (e.g. &H379). In Listing 1 this is named INDATA. Control data is sent to the printer by the second address following the first (e.g. H37A), named CTLDATA in Listing 1.

It should be noted that the PC inverts the Strobe line output, hence the apparent contradiction between the Strobe value in Listing 1 and the Strobe value shown in the timing graph of Fig.1.

In Listing 1 it will be seen that Strobe is only pulsed for the duration of one command. With the 120MHz PC on which this routine was tested, the delay between the two commands that toggle Strobe was measured to be about 5µs, more than enough to comply with the timing requirements shown in Fig.1. With PCs having a much faster clock it may be necessary to put a delay between each of the output commands, for example:

```

OUT OUTDATA, D
FOR E = 1 TO DELAY: NEXT
OUT CTLDATA, 255
FOR E = 1 TO DELAY: NEXT
OUT CTLDATA, 254

```

where DELAY might, perhaps, be given a value of 10 (or even much more) in order to extend the Strobe pulse length.

Try Listing 1 on your PC, with the DELAY included until you know whether or not you need it. It will be necessary, of course, to check which PORT value you need to use, as commented earlier.

Immediately on running the program you should hear the printer respond, and then stop. Winding the paper forward a bit you should see that the test message has been printed.

Experiment with sending other messages instead, of differing lengths. If you are feeling adventurous, write a program that sends several lines of text to the printer.

When normally using Basic to print text to a printer, you would simply issue the command LPRINT, A\$. What Listing 1 does is to completely bypass the computer's own printing procedure, directly

accessing the printer via the printer port registers.

PRINTER PIN DIRECT ACCESS

For graphics output to the printer, the procedure is just a bit more complicated, but not a lot.

First the printer has to be told that it is to accept a batch of data that it is to treat as its pin-activating (graphics) data. Epson have allocated specific series of ASCII values as command groups that tells the printer it is to treat the next lot of data in a different way than if it were to receive text data (Epson manual pages C-2 to C-8 – Command Lists).

Note that all values from hereon are quoted in decimal unless stated otherwise.

The first control command is ASCII 27, which is also known as the ESCAPE command, ESC for short. It is, perhaps, after this command name that Epson's printers are known as ESC/P and ESC/P2. It is a command that has to precede any group of control commands.

To put the printer into its "command" mode, the ESC command (27) is sent to the printer in the same way that text data was sent in Listing 1:

```
D = 27: GOSUB PRINTDATA
```

Next the ASCII value 42 (the asterisk symbol) is sent, telling the printer that it is being put into one of its graphics modes (Select Bit Image, page C-176).

```
D = 42: GOSUB PRINTDATA
```

DOT DENSITY

It is now necessary to tell the printer the dot density required and the number of graphics data bytes that will follow.

In the Epson manual (C-177/8 – Dot Density), tables give the value that should be sent to set the required density. The value used by the author with his 24-pin printers is 6. This sets the horizontal density at 90 dots per inch (dpi), a vertical density of 60 dpi, with adjacent dot printing, 8 dots per column, and 1 byte per column. (For a 9-pin ESC/P printer this value would produce the same results for all parameters except vertical density, which would become 72 dpi.) The density setting is thus sent as:

```
D = 6: GOSUB PRINTDATA
```

The number of graphics data bytes to be sent will vary with what we want to send to the printer. Let's suppose we want to send 300 bytes.

The quantity value is sent as two 8-bit bytes (page C-176), first LSB (least significant byte) followed by MSB (most significant byte). The MSB is obtained by dividing the quantity by 256 and ignoring the remaining fraction. In this case the MSB is $300/256 = 1$. The LSB is simply $300 - (1 \times 256) = 44$.

In Basic, the calculation can be done as:

```
MSB = 300/256: LSB = 300 - (MSB * 256)
```

where the backslash ("\ \backslash ") division command automatically tells Basic that the

MSB is to be an integer. Another way of doing it would be to use the integer command (INT) with the forward slash division command ("/") and say: $MSB = INT(300/256)$. You could alternatively use the MOD (modulo) command to obtain the LSB, i.e. $LSB = 300 \text{ MOD } 256$.

The number of data bytes that will follow is thus sent as:

```
D = LSB: GOSUB PRINTDATA
D = MSB: GOSUB PRINTDATA
```

Now the next 300 data bytes will be treated as instructions to the printer that it is to activate its pins according to the binary representation of the data value received. The printer head automatically moves across the paper by one position for each data byte received. The amount of forward movement is according to the horizontal density value previously set.

GRAPHICS IMAGE

To understand how a graphics image can be printed, imagine that an 8-pin printer head has its pins numbered as follows:

Pin 7 (top)	= 128 (binary bit 7)
Pin 6	= 64 (binary bit 6)
Pin 5	= 32 (binary bit 5)
Pin 4	= 16 (binary bit 4)
Pin 3	= 8 (binary bit 3)
Pin 2	= 4 (binary bit 2)
Pin 1	= 2 (binary bit 1)
Pin 0 (bottom)	= 1 (binary bit 0)

To activate the topmost pin (pin 7), you would simply send a decimal value of 128. To activate pins 5 and 3 together you would send $(32 + 8 = 40)$. To activate them all together you would send 255 (the total of all bit values).

For example, you could send 300 bytes of data that would activate the pins in a strict incrementing sequence from 0 to 255, roll over to zero and then continue upwards again until all 300 bytes had been sent.

Such a sequence, following the sending of the data quantity LSB/MSB, would be sent as:

```
D = 0
FOR A = 1 TO 300
  GOSUB PRINTDATA
  D = (D + 1) AND 255
NEXT
D = 13: ' carriage return
GOSUB PRINTDATA
D = 10: ' line feed (optional)
GOSUB PRINTDATA
```

where D is incremented by one each time round the loop, with the AND 255 statement limiting D to a maximum value of 255, after which it repeats incrementing again from zero. Try it, and observe the pattern created on the paper.

Note that after the full batch of data has been sent for any line, a carriage return command (ASCII 13) must always be sent. It may often be desirable (but not essential) to follow it by sending a line feed command (ASCII 10). The latter depends on whether or not you actually want the paper to move upwards by one step.

EQUALITY

It is important to note that if the amount of data sent does not correspond to the

amount that the printer is expecting (as advised by sending the LSB/MSB earlier), the printer will not respond correctly.

If too little data is sent, the printer will wait until more is received, probably not having actually printed any data to the paper yet. If too much is sent, the printer is likely to consider the excess data as text characters, and some strange symbols may well be printed.

Always send the same amount of graphics data as is expected, and follow that data by a carriage return. (It is not necessary to tell the printer how many text characters are to be sent.)

It is necessary to always precede any batch of graphics data bytes with the commands discussed, i.e.:

```
D = 27: GOSUB PRINTDATA
D = 42: GOSUB PRINTDATA
D = 6: GOSUB PRINTDATA (or value
                        selected from C-176/8)
D = LSB: GOSUB PRINTDATA
D = MSB: GOSUB PRINTDATA
(Now send all graphics values as required)
D = 13: GOSUB PRINTDATA
```

PRINTER INITIALISING

All the foregoing has been carried out on the assumption that the printer is freshly switched on and has not been used in any other way. In other words, it is still in its Reset mode, as is actioned at the time of switch on.

However, such might not be the case – the printer may already have had other commands sent to it by another program, commands which may not apply to the way in which you wish to use the printer.

Consequently, prior to sending data to the printer, it is preferable that you ensure it is in the mode required. The first set of commands to be sent, therefore, is a pair of Reset commands. These take the following form (page C-199 – Initialize Printer):

```
D = 27: GOSUB PRINTDATA: ' ESC
D = 64: GOSUB PRINTDATA: ' @ symbol
```

It is then desirable (but not always necessary) that you set the line spacing that the printer will increment by each time the line feed command is given. For the PIC interface to be described later, an increment of 24/180-inch has been selected to suit the graph to be drawn. The manual shows the requirements on page C-55 (Set N/180 Inch Line Spacing).

```
D = 27: GOSUB PRINTDATA: ' ESC
D = 51: GOSUB PRINTDATA: ' ASCII
value for symbol "3"
```

```
N = 24: D = N: GOSUB PRINTDATA:
' where N sets the spacing
```

All five commands should be sent before sending other data.

PIC EQUIVALENT CODE

Let's now show how the Basic codings are translated to PIC. There's actually not a lot difference! For instance:

```
MOVLW 27
CALL PRINTIT
```

is the PIC equivalent of the Basic:

```
D = 27: GOSUB PRINTDATA
```

LISTING 2. Printer Initialisation

```
INITPRINTER:  ;  
    MOVLW 27    ; ESC  
    CALL PRINTIT ; send to printer  
    MOVLW 64    ; @  
    CALL PRINTIT ; send to printer  
    RETURN
```

LISTING 3. Set n/180 line spacing

```
SETLINE:      ;  
    MOVLW 27    ; ESC  
    CALL PRINTIT  
    MOVLW 51    ; 3  
    CALL PRINTIT  
    MOVLW 24    ; n = 24  
    CALL PRINTIT  
    RETURN
```

The essential command routines are shown in Listings 2 to 7.

In these listings, the PIC's Port addresses and their order of pin-to-function allocation have been set previously to suit the layout on the printed circuit board, more on which later.

It is worth noting that different Port and pin allocations can be used to suit other applications of your own design, with the software amended accordingly.

The NOP pauses in the PRINTIT routine provide a delay of about 1 μ s when the PIC is controlled by a 4MHz crystal. The pause will be somewhat longer when a

LISTING 4. Send data to printer

```
PRINTIT: MOVWF PORTD    ; output data val held in W  
    NOP                ; 1 cycle pause – about 1 microsecond  
    MOVLW STROBELO      ;  
    MOVWF PORTC          ; output STROBE low to printer  
    NOP                ; 1 cycle pause – about 1 microsecond  
    MOVLW STROBEHI      ;  
    MOVWF PORTC          ; output STROBE high to printer  
    NOP                ; 1 cycle pause – about 1 microsecond  
    WAITBUSY: BTFSC PORTC,BUSY ; wait till BUSY goes low  
    GOTO WAITBUSY  
    RETURN
```

3-2768MHz crystal is used, as it is in the accompanying circuit design.

Believe it or not, that is basically all there is to sending data to the printer from a PIC. However, one other principle aspect will be discussed later: how to plot a continuous graph to paper when data logging.

First, though, a practical circuit design for PIC-controlling an Epson dot-matrix printer is described.

INTERFACE CIRCUIT DIAGRAM

A PIC16F877 microcontroller was chosen as the base through which PIC to printer interfacing could be demonstrated. The circuit diagram is shown in Fig.2.

In brief, IC2 is the PIC microcontroller, which is operated at 3-2768MHz as set by crystal X1. Op.amp IC1a is configured as a

LISTING 5.

Carriage return command

```
CARRIAGE:  
    MOVLW 13    ; cause carriage return  
    CALL PRINTIT  
    RETURN
```

LISTING 6. Line feed command

```
LINEFEED:  
    MOVLW 10    ; line feed  
    CALL PRINTIT  
    RETURN
```

d.c. unity gain buffer whose output is fed to one of IC2's analogue-to-digital conversion (ADC) pins, RA0/AN0.

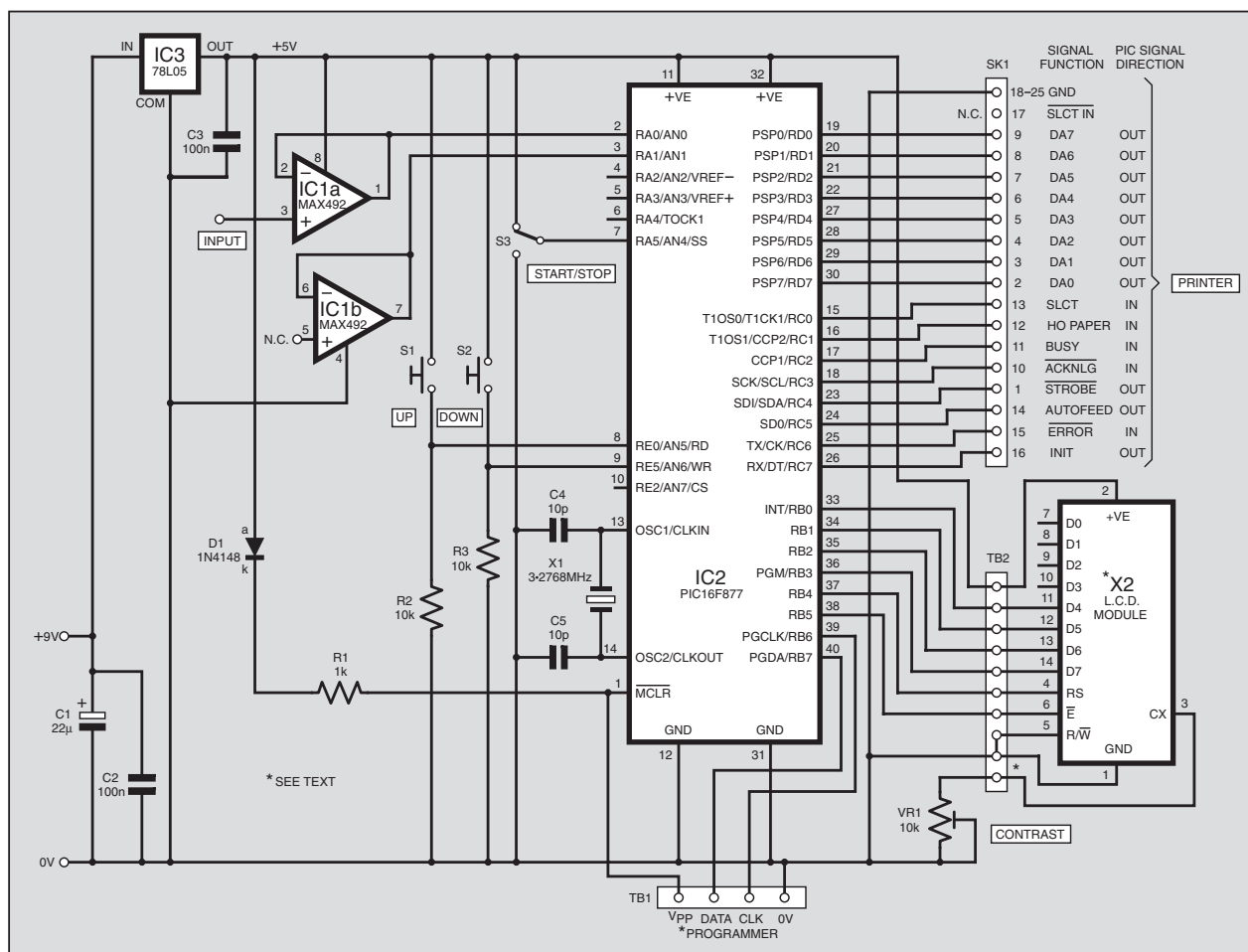


Fig.2. Complete circuit diagram for the PIC to printer data logging interface.

LISTING 7.

Set line length command

LINELENGTH:

```
MOVFB LSB,W ; get LSB, set previously
CALL PRINTIT ; send LSB
MOVFB MSB,W ; get MSB, set previously
CALL PRINTIT ; send MSB
RETURN
```

A second op.amp buffer, IC1b, is shown but it is not actually used in this design. You might find it useful if writing your own software for some other application.

Pushbutton switches S1 and S2 allow the PIC's data sampling rate to be set up or down (range one sample every 1 to 255 seconds). Switch S3 causes the PIC to start or stop sampling and printing.

Liquid crystal display module X2 provides visual readout for various messages to help in your use of the design as a data logger. Its connections and controlling software are the same as has become traditional for this author's PIC-based designs that use alphanumeric I.c.d.s. Preset potentiometer VR1 sets the I.c.d.'s contrast.

COMPONENTS

Resistors

R1 1k
R2, R3 10k (2 off)
All 0.25W 5% carbon film

Potentiometer

VR1 10k preset, min. round

Capacitors

C1 22 μ radial elect. 16V
C2, C3 100n min. ceramic (2 off)
C4, C5 10p min. ceramic

Semiconductors

D1 1N4148 signal diode
IC1 MAX492 dual rail-to-rail op.amp (or similar)
IC2 PIC16F877 PIC microcontroller (see text)
IC3 78L05 +5V voltage regulator

Miscellaneous

S1, S2 s.p. min. push-to-make switch (2 off)
S3 s.p.d.t. min. toggle switch
SK1 25-way Centronics connector, female, right-angled, p.c.b. mounting
X1 3.2768MHz crystal
X2 2-line 16-character (per line) alphanumeric display
TB1 4-way pin-header strip
TB2 4-way + 6-way pin-header strips

Printed circuit board, available from the EPE PCB Service, code 308; case to suit (see text); 8-pin d.i.l. socket; 40-pin d.i.l. socket; p.c.b. supports (4 off); connectors to suit TB1 and TB2; connecting wire; solder, etc.

Approx. Cost
Guidance Only

£30

excluding case.

TABLE 1. Printer Connector Pin Functions

Pin	Signal	Direction	Function
1	STROBE	In	STROBE pulse for printer to read incoming data. Pulse width must be more than 0.5 μ s.
2 to 9	DATA 1 to 8	In	These signals present information of bits 1 to 8 of parallel data, respectively. Bit 1 = LSB, Bit 8 = MSB. Logic 1 = High, Logic 0 = Low.
10	ACKNLG	Out	About an 11 μ s pulse. Low indicates that data has been received and that the printer is ready to accept more data.
11	BUSY	Out	A High signal indicates that the printer cannot receive data. The signal goes High in the following cases: 1. During data entry 2. During printing 3. When off-line 4. During printer error state
12	PAPER	Out	A High signal indicates that the printer is out of paper.
13	SELCT	Out	Pulled up to +5V through a 3k3 resistance.
14	AUTO FEED	In	When this signal is Low, the paper is automatically fed 1 line after printing.
15	NC		Not used
16	GND		Logic ground level
17	CHASSIS GND		Printer's chassis ground which is isolated from the logic ground.
18	NC		Not used
19 to 30	GND		Twisted pair return signal ground level.
31	INIT	In	When this becomes Low, the printer controller is reset to its power-up state and the printer buffer is cleared. This level is normally High. Its pulse width must be more than 50 μ s.
32	ERROR	Out	This level becomes Low when the printer is: in paper out state; off-line; in error state.
33	GND		Same as for pins 19 to 30
34	NC		Not used
35	—	Out	Pulled up to +5V through a 3k3 resistance.
36	SLCT IN	In	The level of this signal is factory-set to Low (see Epson manual).

PROGRAMMING

The PIC can be programmed on-board via the TB1 connector pins, which are in the author's standard order. *PIC Toolkit Mk2* is a suitable unit for programming the software into the PIC. Diode D1 and resistor R1 prevent distress to the circuit's 5V supply when programming is in progress.

The circuit may be used with a d.c. power supply of between about 7V and 15V. IC3 regulates the input voltage down to the 5V supply required by the circuit. *This 5V voltage level must not be significantly exceeded for fear of damaging the PIC, I.c.d. and printer.* A deviation of about 10 per cent (but no more) is permissible.

PRINTER CONNECTIONS

Refer now to Fig.3 and to Table 1. Fig.3 shows the connections at the printer (36 pins) and at what is normally the computer end of the setup (25 pins). Table 1 shows the pin assignments for the standard 36-way Centronics parallel interface connector, as used at the printer end.

The demo p.c.b. uses a 25-pin connector so that a standard Centronics printer cable can be used between the unit and the printer. If you have a printer you should already have this cable!

CONNECTION FUNCTIONS

In the earlier discussions, we examined the functions for the DATA, BUSY and ACKNLG lines. It seems unlikely that the PAPER, ERROR, AUTO FEED and INIT functions listed in Table 1 will find use in a PIC-controlled printer interface.

For the first two functions, the reading of the BUSY line provides the answer to whether or not the PIC is to send more data. Line Feed and Initialisation (INIT) functions can be performed through software. Functions SLCT and SLCT IN are probably only of use when several printers are chained. See the Epson manual for details of the functions not discussed.

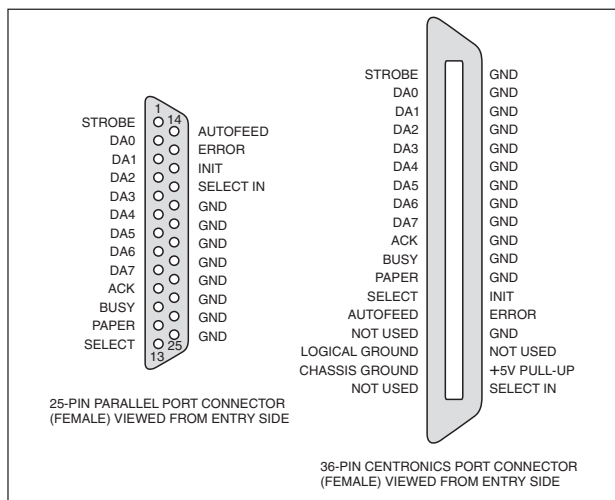


Fig.3. Parallel printer port connectors. Left: Output from PC or PIC to printer interface. Right: Input to dot-matrix printer.

Although some functions are not implemented through the demo software, the p.c.b. provides connections between the PIC and all function lines except SLCT IN.

Data lines are connected to PIC PORTD, and Control lines to PORTC. If you are designing a board for another circuit of your own invention, you could probably omit the PIC connections for the SLCT, PAPER, ACKNLG, AUTO FEED, ERROR and INIT functions. This would allow you to control the printer via only 10 lines, DATA \times 8, STROBE and BUSY.

Consequently, if the ADC and l.c.d. readout facilities are not needed, you could actually control the printer from a PIC16F84. This would leave three pins for other purposes. The use of the DATA lines could also be multiplexed between the printer and other external circuits.

It would seem desirable to connect a resistor between the printer's unused inputs and 0V or +5V (see Table 1 for which power level is appropriate for which pin). A suggested resistor value is 3k Ω – as used by Epson on a couple of lines as shown in Table 1).

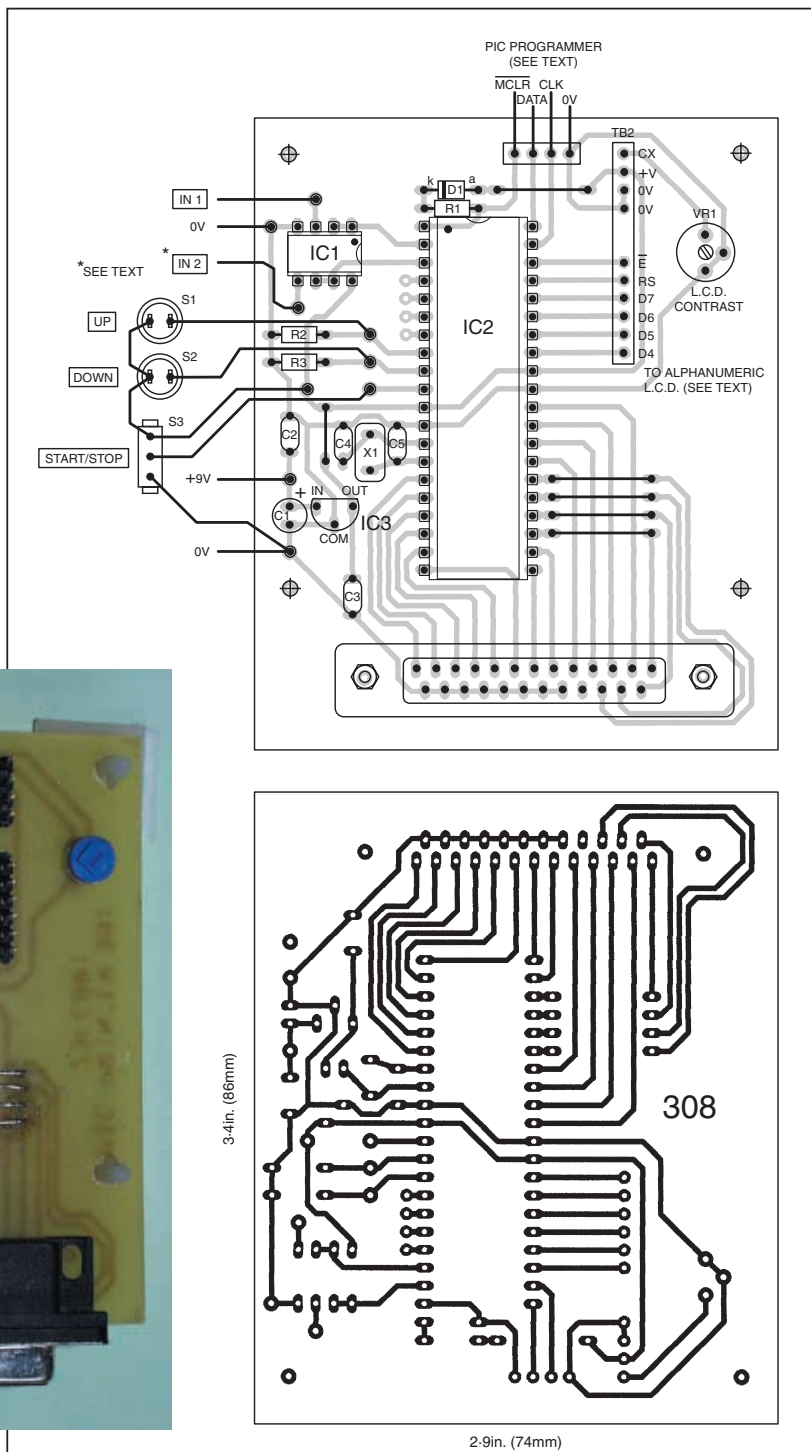
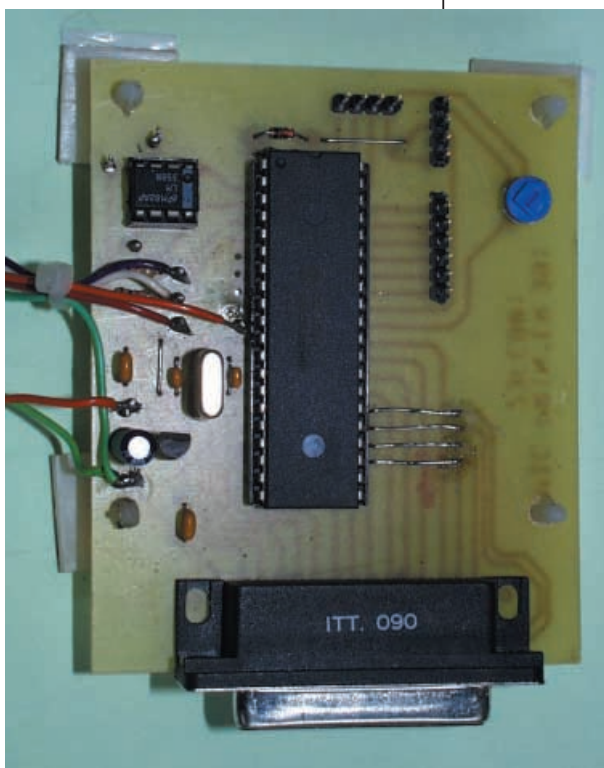


Fig.4. Printed circuit board component layout and full-size master track pattern.

CONSTRUCTION

The printed circuit board component and track layouts for this interface are shown in Fig.4. The board is available from the *EPE PCB Service*, code 308.

First insert and solder the few wire links, then the two d.i.l. i.c. sockets, followed by the remaining small electronic components. Conclude with connectors TB1, TB2 and SK1, and then wire up the switches and power supply.

As seen in the photographs, the prototype was not mounted in a case and the choice of style for this is left to you.

Do not insert IC1 and IC2 or connect the l.c.d. until you have ascertained that the power supply is being correctly regulated down to +5V by IC3.

The PIC microcontroller can be programmed on-board via the TB1 connector, a function which can be performed by *Toolkit Mk2*. The software is available as stated later.

If you intend to use the design simply as a data logger with printer output, you may prefer to use a pre-programmed PIC – they are available as stated in *Shoptalk*.

Before running the unit, first switch S3 to the Stop position. On power-up the programmed PIC will cause a opening message to be displayed on the l.c.d. screen:

SET RATE PRD= 2 on line 1, and
WAITING START on line 2.

The value of PRD= 2 shows that the sampling rate is set for taking samples once every two seconds. The period may be increased, up to once every 255 seconds, by pressing and holding down pushbutton switch S1. The value increments at a rate of twice per second. After 255 has been reached, the sample rate rolls over to 1 (second per sample), omitting the zero step.

Switch S2 allows the rate to be decremented, rolling over to 255 following 1. The sampling rate can only be set prior to switching on S3.

OVER-ACTIVE

It may, incidentally, be found that some printers seem a bit over-active if a



L.C.D. screen prior to printing data to printer.



Typical L.C.D. screen during printing.

sampling rate of once per second is chosen, hence the default value of 2. This was the case for the author's inkjet colour printer, although once per second did not make his dot-matrix printers seem over-active.

When S3 is switched, the message on the screen changes to just show the period (PRD) value on line 1, whilst line 2 changes to state WAITING PRINTER. If the printer is not ready (not switched on, cable omitted, paper out, etc), the screen will remain in this mode until the printer is ready.

The printer's status is first determined by reading its ACK line, with the statements:

```
WAITACK: BTFSS PORTC,ACK
        GOTO WAITACK
```

This causes the program to wait until the ACK line goes high, which is its normal status when the printer is switched on.

Then, once ACK is high, and as part of the sending data process, the BUSY line is read to determine if it is low, as discussed earlier.

CLOCKING-UP

When the printer is ready the L.C.D. top line will display an hour-minutes-seconds clock counter, counting upwards from zero. The clock counts in seconds intervals, irrespective of the sampling rate selected. Note that it will stop counting if the printer detects an error condition (paper out, etc). It will not detect if the printer is switched off since BUSY will automatically go low in this instance, or if the cable is disconnected.

Line two shows the value of the last sample that the PIC has taken via its analogue input, RA0, ranging between 0 (0V) and 255 (+5V approximately – actually the line voltage value at which the PIC is being powered).

If no signal input is applied to the op.amp, IC1a, the PIC's RA0 input will see a voltage midway between the two power voltages, about 2.5V, resulting in a DATA value of around 127.

At the right of line 2, a counter keeps track of the number of samples taken since printing commenced, e.g. TL= 9. TL can reach 9999, after which it rolls over to zero and starts counting upwards again.

When the printer starts running following S3 being switched on, a text line is printed first, confirming the sampling rate, e.g.:

SAMPLING SET FOR ONCE PER 10 SECONDS

A second line is then printed which corresponds with graph lines that are printed while samples are plotted. The intervals are 0, 1/4, 1/2, 3/4 and MAX.

From then on, sampling clock time is printed at the left of paper, once every eight samples. The printer then prints a series of dots between the value of the previous sample and the current one, so drawing what is effectively a continuous graph line.

It is up to you to actually write on the paper the actual date and time that printing commences.

The full graph sweep is from 0 to 255. If a sample has the same value as the previous one, a single dot is placed beside the last one (as one would expect, of course!).

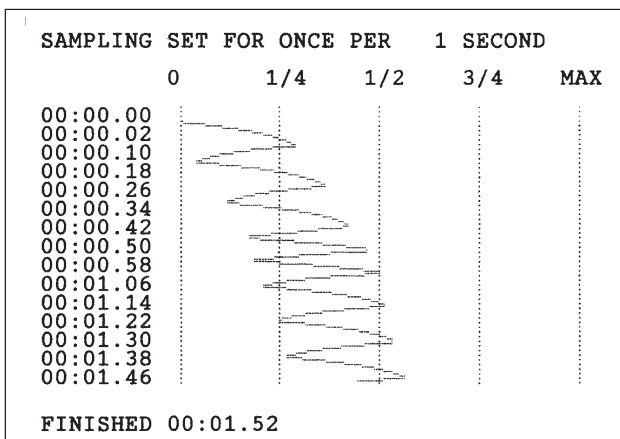


Fig.5. Example printout of waveform received by the PIC to Printer Interface.

TERMINATING

Sampling and printing may be terminated at any time by switching off S3. The printer responds by printing the finishing time (elapsed time since printing began). Then follow two line feeds, and the printer stops. The L.C.D. screen reverts to showing WAITING START (etc) when S3 is switched off.

Note that the printer may actually continue to print for a short while after S3 has been switched off, emptying its buffer memory of any remaining data.

Also be aware that S3 being switched off will not be responded to if the printer is in an error condition. To terminate the PIC sampling routine in such an instance, the error condition must either be removed, or the PIC's power supply switched off. No harm can come to the PIC while it is held "in limbo" by a printer error, it simply sits in a holding loop until the BUSY line goes low.

To test the unit, it suggested that you first leave the input to IC1a unconnected, causing a midway-value trace to be plotted by the printer. Next, using a meter lead perhaps, connect IC1's input to 0V for a while, after which connect it to the 5V rail for a further period. The printed graph should show all three sampling voltage levels, min, mid and max.

DATA REVERSAL

The software uses variations on the control routines discussed earlier in the article. There are two aspects, though, that deserve further discussion. First, a "reversal" of the data sent to the printer:

The printed circuit board has been configured so that connections to the 25-pin socket are made in the most convenient order, without lots of cross-over links. This has meant that the pinouts from DATA PORTD are in the opposite order in relation to the DATA pins of connector SK1.

Consequently, on entry to the PRINTIT routine a data byte reversal routine is first called (REVERSE – see Listing 8) which rearranges the binary logic to the correct bit order. For instance, binary 10101010 becomes 01010101.

RASTERFAREAN

The second aspect concerns the way in which adjacent sampling values are plotted:

LISTING 8. Reverse order of bits to suit p.c.b. layout

```
REVERSE: MOVWF STORE1 ; store data val brought in on W
          MOVLW 8 ; set loop val for 8 bits to reverse
          MOVWF LOOPA
REV1: RRF STORE1,F ; rotate right STORE1 into Carry
      RLF STORE2,F ; rotate left Carry into STORE2
      DECFSZ LOOPA,F ; decrement loop until all 8 bits done
      GOTO REV1
      MOVF STORE2,W ; call STORE2 into W as reversed order val
      RETURN
```

Each sample value is compared against the previous one. From this the start and end points for the printing of the graph dots for one "raster" line are determined.

From a zero position (beyond the "time stamp"), the printer is fed with a series of zero values, until the dots-start position is reached. Then the dots sequence is commenced, in which just one printer head pin is activated. After this sequence, further zero values are fed to the printer, until a total of 256 printing commands have been issued for that line.

During the 256 commands sequence, the software automatically activates four printer pins at the graph line positions, creating the dotted graph reference lines.

PIN HEAD CYCLE

When writing the software, the author recognised two ways in which adjacent printing lines could be kept close, either by shifting the line feed by a very small value, or by changing the pin number activated between adjacent lines. It is this latter technique that is employed.

Track is kept of the number lines being printed. Pins are activated in relation to this count value, on a cycle of eight (effectively, the software establishes the "modulo-8" value of the count).

On the modulo value equalling 0, only pin 7 (value = 128, see earlier) is the one activated for that line. On the next line, pin 6 becomes the only active one (= 64). And so on until pin 0 (= 1), after which the next pin number will again become 7.

Each time the modulo value equals zero, a line feed command is issued, which moves the paper forward by an amount that keeps all line groups equally spaced.

Immediately following this, the next elapsed time value is printed.

It is worth noting that the author's *inkjet* printer appears to shift the print head across the paper three times for each sample. This may be a situation for which a prohibitive command might be available, but the author has not investigated it. It is of no significance to the printed results.

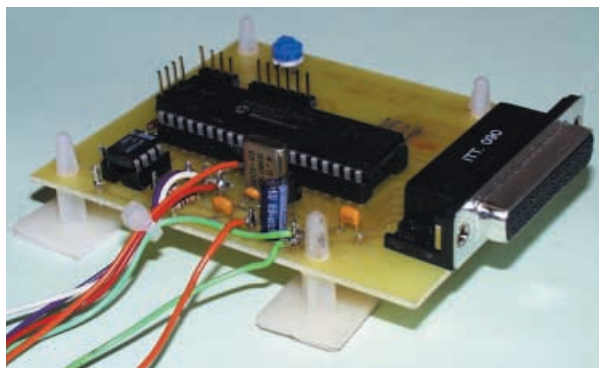
CONCLUSION

So there we have it – how a PIC can be interfaced to an Epson-compatible dot-matrix printer, and how you can use this facility as a hard-copy, time stamped, data logger and plotter. Thank you Andy Daw for making the suggestion, the author enjoyed implementing it!

It is hoped that you now feel encouraged to experiment with the many other printer commands described in Epson's reference manual.

RESOURCES

The software for this project was written in TASM and is available as source code, HEX code and OBJ code on 3.5-inch floppy disk from the *EPE* Editorial Office (a nominal handling charge applies). It is also available for free download from the *EPE* ftp site. For more details of both methods, see *Shoptalk* elsewhere in this issue, or the *EPE PCB Service page*.



Epson's web site, from where you can download the free Acrobat-based reference manual, is at www.epson.com. There are several files involved. The one that includes all Epson's commands is the first one, *EpsonPart1(1).pdf*, and includes all the "C-" referenced pages mentioned during this article.

It is well worth downloading the other Epson manual files as well, since many other printer control aspects are covered in them, some of which relate to specific models of printer.

All commands discussed earlier are believed to be available on all Epson dot-matrix models.

Incidentally, the software for this PIC to Printer Interface was developed on the author's new *Toolkit TK3 For Windows (Toolkit Mk3)*, which will be published in the October 2001 edition. *TK3* has full stand-alone operation and has many functions available, including Internet and MPASM access. □



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PERPETUAL PROJECTS

THOMAS SCARBOROUGH



- **Solar-Powered – No batteries** ● **Uses a common – Uniboard – p.c.b.**
- **Will run indefinitely, without attention** ● **Ideal for the novice.**

A series on “solar powered” projects that will run unattended for months – in fact, for years or even centuries!

THIS four-part series includes eight “perpetual” projects, all of which will continue to run indefinitely without attention. All are based on one small p.c.b. called a “Uniboard”. Each project is powered around the clock – perpetually – by a one Farad “Goldcap” capacitor (memory backup) and a small solar cell (no battery). Each is designed for continuous operation with a maximum of thirty minutes sunlight a day – in fact just *five minutes sunlight* with the specified 300mW solar panel.

In Conception

The concept in itself is a simple one, however it required considerable experimentation, and a little ingenuity, to obtain around-the-clock operation for every project in the series. A number of “micropower” i.c.s were at first tested for suitability, but virtually all fell short – some consuming 60µA, some 100µA, some even 500µA when in use. This was not nearly good enough to see a “Goldcap” through a long night.

Finally, a veteran among i.c.s delivered a nice surprise – the 4093 quad 2-input NAND Schmitt trigger showed that it was capable (for instance) of perpetually flashing an l.e.d. (light-emitting diode) with just 15µA power consumption when the Motorola version (MC14093BCP) was used.

To put this in perspective, the typical power requirements of one of these Perpetual Projects is more than *one thousand times* less

than the requirements of an ordinary l.e.d., and *thirty times* less than those of the “efficient” LM3909 l.e.d. flasher i.c.

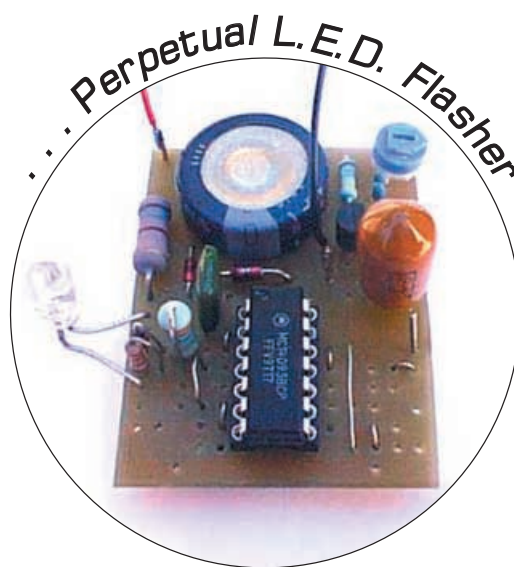
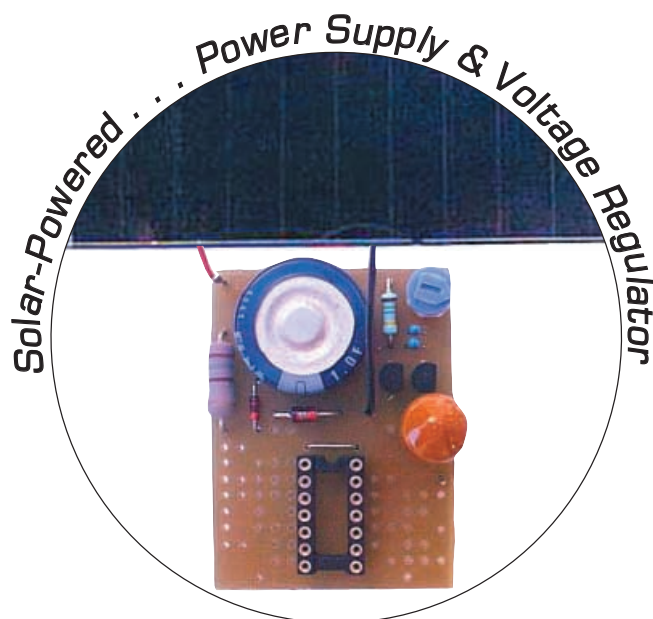
Projects at a glance:

- | | |
|-----------------------------|------------------------|
| ☆ L.E.D. Flasher | ☆ Rain Alarm |
| ☆ Loop Burglar Alarm | ☆ Gate Sentinel |
| ☆ Double Door-Buzzer | ☆ Bird Scarer |
| ☆ Door-Light | ☆ Register |

Besides the projects listed here, the series includes nine suggestions for modifications. These include a Single Door-Buzzer, a Broken Beam Beeper, a Power Failure Alarm, a Soil Moisture Monitor, a Thermistor, a Timer, a Liquid-Level Alarm, a Wake-Up Alarm, and a Break Contact Alarm.

Design Considerations

The “all-purpose” 4093 quad 2-input NAND Schmitt trigger i.c. has a great many potential applications. It may even be used as the heart of radio receivers and metal detectors. However, only projects thought to be *practical* perpetual projects have been selected.



A decision was made early on to limit the designs to a single active component, namely the 4093 CMOS i.c. (regulator components excepted). No additional i.c.s or transistors are employed. Thus – it might be said – we have here a series of *pocketable* practical perpetual projects!

Some circuits which seemed to be candidates for the series at first needed to be omitted from the main line-up because they were not strictly “perpetual”. Due to higher current consumption, they would have shut down some time before sunrise. Nonetheless, some of them would have been very useful, and are therefore included in the series under “Suggestions”.

In particular, those circuits which teetered too long on the edge of triggering (that is, which involved slow-moving analogue signals, such as a thermistor or soil moisture monitor) did not meet the necessary power requirements. If gates are held at a level close to triggering, the 4093 i.c. will consume 60µA at 3V (some makes will consume up to 200µA), although this may be reduced a little with a simple trick.

Under normal circumstances, such power consumption would be negligible – however, power consumption must average 20µA or less to see one of these *Perpetual Projects* around the clock.

It was decided to use *touch switches* throughout the series, since the symbolism of the “perpetual” might be compromised if any mechanical switches were included – particularly if these would interrupt the power supply. The *option* of mechanical switches is included, since touch switches may become troublesome in a wet or damp environment.

Conservation

An important design consideration throughout the series is that, as far as possible, no oscillator should run “in the background” – that is, oscillate while a piezo disc or l.e.d. is disabled. It is possible, for instance, to silence a piezo sounder by switching off a buffer, while the oscillator behind it remains active.

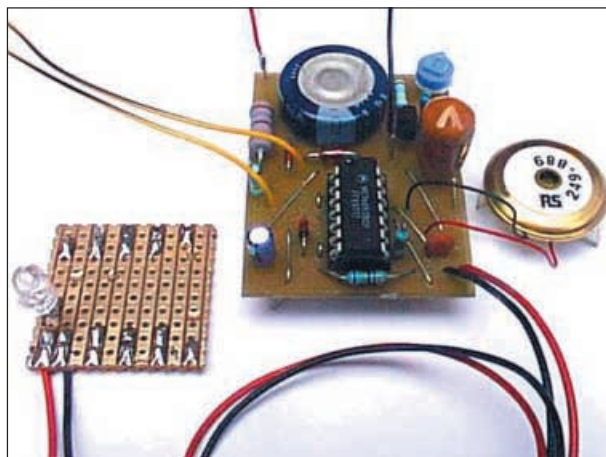
In order to conserve power, each oscillator needs to be shut down when not in use. In some of the projects, such “background” oscillation (if it were permitted) would exhaust the “Goldcap” capacitor well before it could go around the clock.

But first we must turn our attention to the most distinctive aspects of this series – the solar-powered power supply and voltage regulator for all these projects.

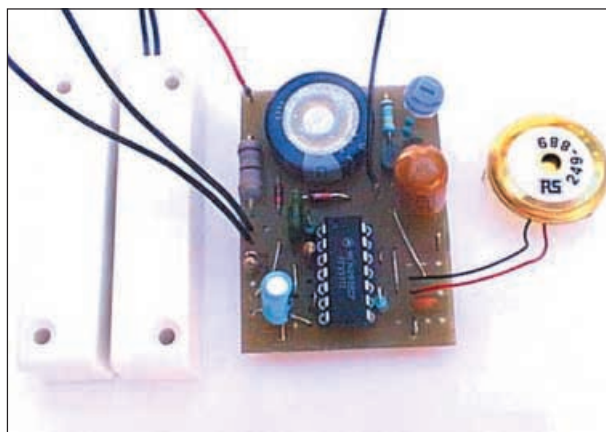
It might be worth noting at this stage that the biggest outlay for the Perpetual Projects lies in the power supply and regulator components. Once these have been purchased, the cost of the projects which follow will be well below £10 each.

It now only remains for you to choose the Perpetual Project that appeals to you and await its publication. Better still, to avoid

... Rain Alarm

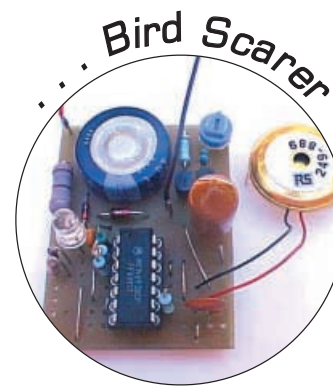
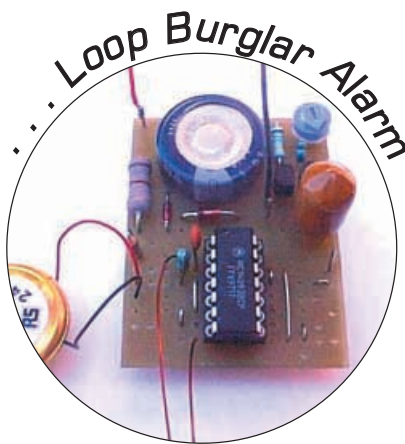
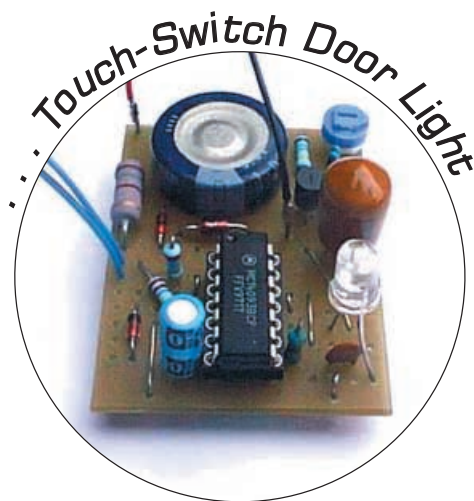


... Gate Sentinel



missing that particular issue, why not place a regular order for *EPE* at your local Newsagent (or take out a Subscription) and experiment with *all* these forthcoming Solar-Powered projects?

TURN OVER FOR FIRST PROJECT



SOLAR-POWERED POWER SUPPLY & VOLTAGE REGULATOR

THOMAS SCARBOROUGH

Free power for your projects!



BEFORE we undertake the construction of the first practical circuit of our Perpetual Projects for this series (next month) we must consider the power supply requirements and construct a suitable unit that will cater for all the various circuit designs. All the projects are built on a low-cost Uniboard (printed circuit board – one required for each project, unless you are expert at desoldering!), which also includes the Solar-Powered Power Supply and Voltage Regulator circuit described here.

The Solar-Powered supply section is only required once, unless you wish to build and keep all the projects as separate modules. Once the power supply and regulator components have been purchased, the cost of the other projects which follow is in the region of £5 each (excluding p.c.b.).

POWER SUPPLY

The full circuit diagram for the Solar-Powered Power Supply and Voltage Regulator is shown in Fig.1. Capacitor C1 is charged by means of the solar cell X1, which provides 6V to 12V, and 10mA upwards – that is, a relatively small solar cell will provide adequate charge.

Note that 12V should be the maximum actual unloaded output of the solar cell in full sunlight – therefore one having a load voltage rating of 6V or 7.5V will most likely suit. A higher voltage solar panel could be used, but the value of resistor R1 would need to be adjusted so that $V_{MAX}/R < 75mA$.

The voltage from the solar cell is regulated by Zener diode D1. Resistor R1 ensures that D1 and rectifier diode D2 are never overloaded. Diode D2 prevents reverse leakage of current, and its inclusion (with solar cell disconnected) extends the charge holding time of C1 more than ten-fold.

Diode D2 drops about 0.7V, therefore the highest voltage that will be found across capacitor C1 is

4.9V. This ensures far better regulation than if C1 were charged to capacity – in fact, a fully charged C1 does not confer much more life on the circuit. Note that capacitor C1 should never be *directly* attached to the solar cell, since its maximum rating is 5.5V. It is easily damaged, as well as expensive, and needs to be treated with care.

Capacitor C1 is quickly charged in full sunlight. With a small 6V 10mA solar cell receiving full sunlight, it will be fully charged within 30 minutes. A 12V 100mA solar cell will charge C1 in *less than a minute*.

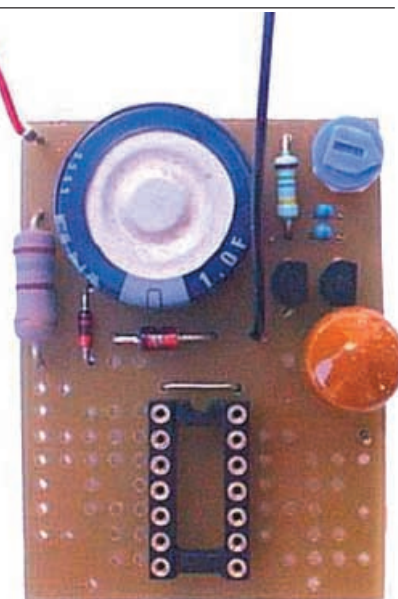
Capacitor C1 cannot be over-charged, nor can the solar cell overload any of the projects, so long as its maximum output is an *actual* 6V to 12V.

VOLTAGE REGULATION

A capacitor behaves very differently to a battery, in that a battery's voltage goes into gradual decline as it discharges, while a capacitor's voltage generally goes into a "free-fall", then levels out as it reaches a fraction of its starting-point.

Therefore, the secret to obtaining any useful long-term service from a capacitor is to *regulate* its rapidly falling voltage. In this case, this is achieved with the help of bipolar transistor TR1 and f.e.t. TR2.

Field effect transistor (f.e.t.) TR2 is employed in such a way that its conductance is automatically adjusted to keep a



constant voltage across capacitor C2 as the voltage across C1 falls. A f.e.t. was chosen for this purpose since its conductance is voltage- (or field effect) controlled, and it therefore draws only a minute current – a very necessary feature in this application.

The control voltage is provided at the collector (c) of bipolar transistor TR1, which forms part of a variable potential divider, through preset VR1 and thermistors R3 and R4. As the voltage across C1 decreases, so the conductance of TR1 decreases, and the potential at TR1's collector rises. This in turn increases the conductance of TR2.

During the testing of the *Perpetual L.E.D. Flasher* project (next month), the voltage across capacitor C2 held steady for 20 hours before beginning to slip, and had fallen only 5 per cent after 26 hours.

A bipolar transistor with high or medium gain does not serve well in the position of TR1, and a very low gain transistor, the TIPP31C

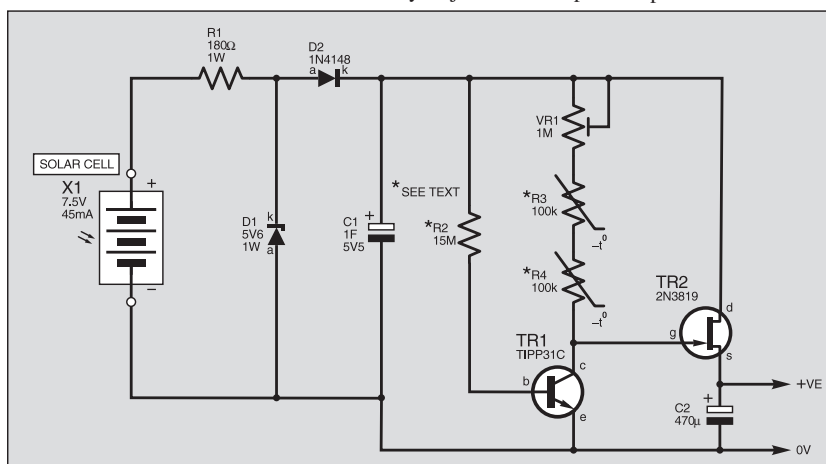


Fig.1. Complete circuit diagram for the Perpetual Projects Solar-Powered Power Supply and Voltage Regulator.

(nominal gain 25) is employed. The TIPP31 and TIPP31B (but *not* the TIPP31A) were also tested successfully. Other equivalents should be chosen with great care.

The f.e.t. regulator consumes around 5µA. A low leakage capacitor should be chosen for C2, since higher leakage can significantly reduce the life of the power supply.

Several types of regulator were tried, but all except two fell short – chiefly because of excessive current drain, or because the voltage across C2 dropped too fast. The present regulator has proved to be the best so far, but it does, however, have one drawback. The more efficient the circuit (the efficiency being determined by resistor R2, thermistors R3, R4, and preset VR1), the more sensitive it becomes to temperature variations.

Therefore, thermistors R3 and R4 are inserted in the variable potential divider incorporating TR1 and VR1. This largely balances the effects of temperature on transistor TR1. The thermistors should be “common” types designed for use between -25°C and +125°C (plus or minus 25°C) – not “industrial” types that might take molten lead in their stride!

IN COMPARISON

An interesting (but very approximate) comparison is made in Table 1 between C1 (a 1 farad memory retention capacitor) and an AA nickel-cadmium rechargeable battery. This also gives a rule of thumb for determining the length of service of any particular project in this series.

The anticipated hours of service of any given Perpetual Project are calculated by dividing capacity (mAh) by actual current consumption (mA).

CONSTRUCTION

Construction of the Solar-Powered Power Supply and Voltage Regulator, which lies at the heart of the series, is fairly straightforward and once the regulator has been constructed, it is over to you to choose which specific project you would like to add to your Uniboard.

Note that all the projects may also be run off batteries. In this case, the solar cell and “GoldCap” capacitor (C1) may be omitted during construction, as well as R1, D1, and D2. A 4.5V battery supply (three AA

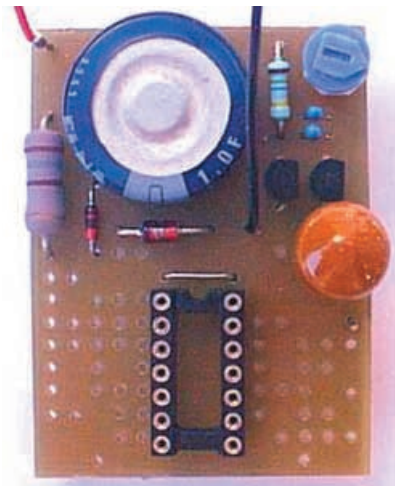
Table 1: Comparison between an AA type NiCad and the 1 farad (“GoldCap”) capacitor, with f.e.t. regulator

AA nickel-cadmium (rechargeable)		One farad capacitor with regulator	
Nominal Voltage:	1.2V	Nominal Voltage:	3V
Nominal Capacity:	500mAh	Nominal Capacity:	0.5mAh
Average Life:	1000 cycles	Average Life:	“Infinite” cycles
Average Charge Time:	14 hours	Average Charge Time:	5 minutes
Shelf Life:	1 year	Shelf Life:	1 day

batteries in series) is connected in place of C1. Be sure to observe the correct polarity.

Most of the Uniboard projects will continue for the shelf life of the batteries (five years in the case of quality alkaline batteries). However, this will inevitably involve the bother (too much for the author!) of replacing batteries every so many years – not to mention that your descendants will need to replace them, too!

The regulator circuit is built up on a small, single-sided, printed circuit board (p.c.b.) and the topside component layout, wiring and details of the underside full-size copper foil master are shown in Fig.2. This board is available from the EPE PCB Service, code 305. If you are going to make your own p.c.b., it is so designed that it may be drilled using a piece of 0.1in. matrix stripboard as a template.



Completed power supply board. Note the miniature thermistors, top right, and the 14-pin i.c. socket.

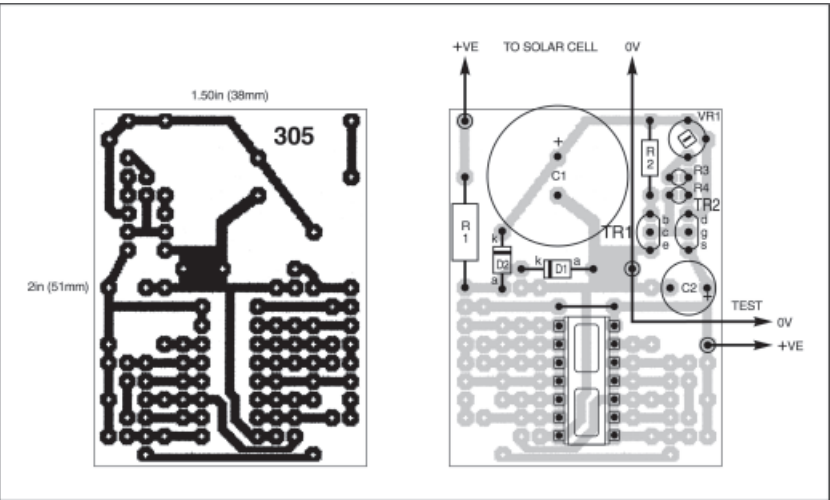


Fig.2. Uniboard Power Supply and Voltage Regulator component layout and full-size copper foil master. Not all the holes/pads are used.

All the components should fit into place without too much difficulty. Start construction by soldering the solder pins and link wire in position, then the resistors, thermistors, and preset VR1, continuing with the diodes, capacitors and transistors. Also insert and solder the dual-in-line socket if you wish to build any of the projects on the same p.c.b. as the Power Supply – they all use the same 14-pin i.c. The leads of the solar cell are taken to the solder pins as shown in Fig.2.

If a single high-value resistor for R2 is unobtainable, you may insert 10 megohm and 4-7 megohm resistors in series to make up the required value. Also, if 100 kilohms at 25°C n.t.c. thermistors are unobtainable,

COMPONENTS

POWER SUPPLY/REGULATOR

Resistors

R1 180Ω carbon film, 1W

R2 15M metal film 0.25W (see text)

R3, R4 n.t.c. thermistor, 100k at 25°C (see text) 2 off

Potentiometers

VR1 1M min. cemet trimmer, single turn (6mm) 300mW

Capacitors

C1 1F 5.5V d.c. low-profile memory back-up, (“GoldCap”) radial elect. 5mm lead pitch

C2 470µ radial resin dipped aluminium elect. 6.3V

Semiconductors

D1 5.6V Zener diode, 1W

D2 1N4148 signal diode

TR1 TIPP31C npn silicon transistor

TR2 2N3819 n-channel field effect transistor (f.e.t.)

Miscellaneous

X1 6V to 12V solar panel, 10mW upwards (see text)

Printed circuit board (Uniboard) available from the EPE PCB Service, code 305; 14-pin d.i.l. socket; multistrand connecting wire; link wire (component lead off-cut); solder pins; solder etc.

Approx. Cost Guidance Only

£20

excl. solar panel

use other values in series to make up about 200 kilohms in all.

Be sure to observe the correct polarity of the solar cell and the two capacitors, and the correct orientation of diodes D1, D2, transistors TR1 and TR2. The cathode (k) ends of D1 and D2 are banded.

SETTING UP

Before we commence the calibration, you should give the p.c.b. one final inspection for any wiring faults, such as “bridged” solder tracks, or wrongly positioned components (particularly as not all the holes/pads are used with each project). If all appears to be correct, you can now leave the solar cell (but not the p.c.b., which should be protected from wide temperature swings) in direct sunlight to charge up capacitor C1.

Give the circuit half an hour in full sunlight to be certain that C1 has fully charged (five minutes if the specified solar panel is used). Then temporarily connect a 180 kilohms resistor (a load resistor) across capacitor C2, and measure the voltage across it. Solder pins are provided for this purpose at both sides of C2.

Turn preset potentiometer VR1 across its full range – this should give you readings from about 2.5V to 4.7V (this may vary according to component tolerances). In the various Uniboard projects, a supply of either 3V or 3.6V will be required. If the voltages measured do not fall within these parameters, experiment with the value of resistor R2 – a higher value for higher voltages, and vice versa.

Note that capacitor C2 causes a delay to any adjustments that are made to the voltage – the circuit does not respond to adjustment of preset VR1 immediately. This means that you will need to allow half a minute or so for the voltage to settle at any particular setting of VR1.

LONG TERM

Since there is plenty of time until next month, why not test the long-term stability of the power supply in the meantime?

Temporarily connect the 180 kilohm load resistor across capacitor C2. Adjust the voltage across C2 to 3V. The current passing through the resistor at 3V will be about $17\mu\text{A}$ ($V/R=I$), which is a little more than the required current for the *Perpetual L.E.D. Flasher* (next month).

All being well, this voltage should hold steady for 18 hours and more before beginning to slip – if not rising slightly in between.

GOING ACTIVE

Having tested and “tested” the Solar-Powered Power Supply and Voltage Regulator, we can now proceed with a general introduction to the *Perpetual Projects*’ single most active component (regulator components excepted), which is IC1 – a 4093 quad 2-input NAND Schmitt trigger.

There are various manufacturers of the 4093 i.c., and the make used in this series is the Motorola MC14093BCP. This does make a difference – the make significantly affects both the power consumption and characteristics of the 4093 i.c. For instance, the GD4093B i.c. roughly doubles the power consumption. Therefore, other 4093 i.c.s may be used as a stop-gap

measure, but are likely to perform inadequately.

Each of IC1’s gates (of which there are four – see Fig.3) switches, or triggers, very decisively between high and low states (logic 1 and logic 0) at its output terminal. Such switching is crucial to these applica-

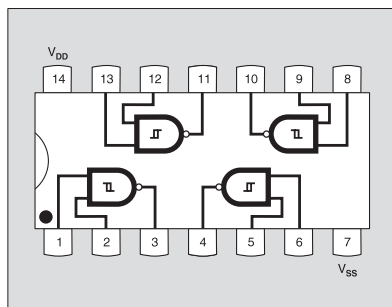


Fig.3. Pinout details for the 4093 quad 2-input NAND Schmitt trigger i.c.

tions – ordinary NAND gates fail to function at all.

The four 2-input gates of IC1 employ, of course, NAND logic. To explain this in the simplest terms, if *both* the inputs of a NAND gate are taken high (to positive), the output is low (or negative). All other combinations of inputs give a high output.

Wires may be taken directly from inputs to the positive or negative rails – or they may be taken high or low *through* a resistor. This also means that *potential dividers* may be used at the inputs, which will be described in more detail as the series progresses.

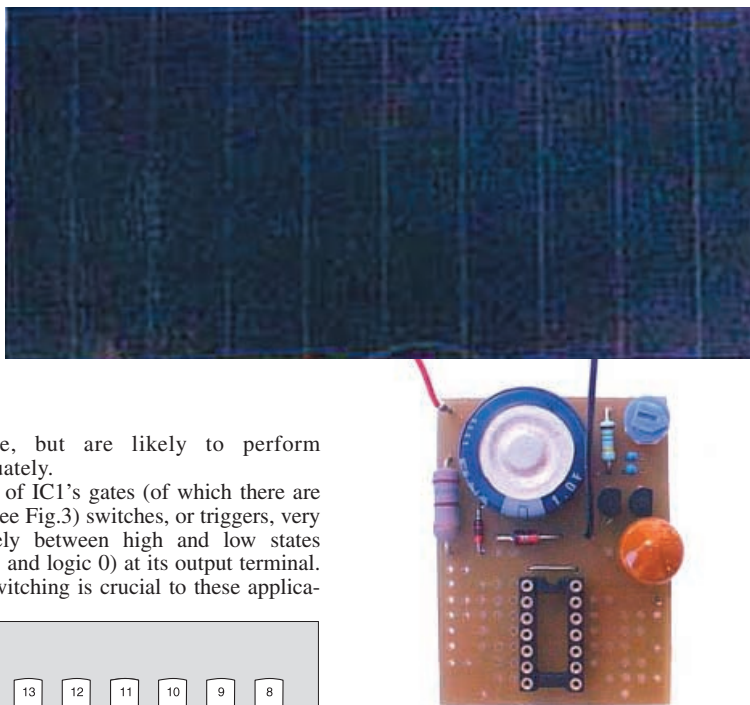
Inputs should not be left “floating” (unconnected), otherwise an input may not know what to do, and is likely to behave erratically. By “tying inputs high”, a significant amount of power (as much as one third) is conserved in the projects which follow.

DELAYED ACTION

One more important aspect of IC1 is that the transition of an input from a low to a high state or vice versa may be *delayed*.

If, for instance, a capacitor (C_X – see Fig.4) is wired between the negative rail (0V) and an Input B, and a resistor (R_X) is wired between Input B and the positive rail, a certain amount of time passes before the capacitor charges, and therefore the transition from a high to a low state is delayed at the output terminal.

Not only this, but as soon as the capacitor’s charge reaches two thirds of the supply voltage (assuming that Input A is high as well), the gate conducts, and the capacitor is



The solar panel wired to the completed power supply circuit board.

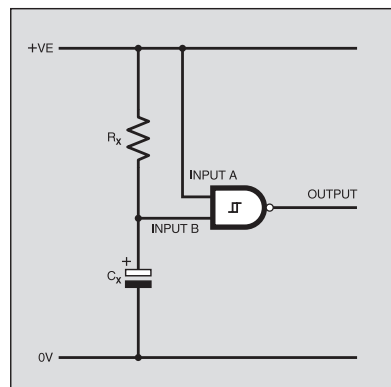
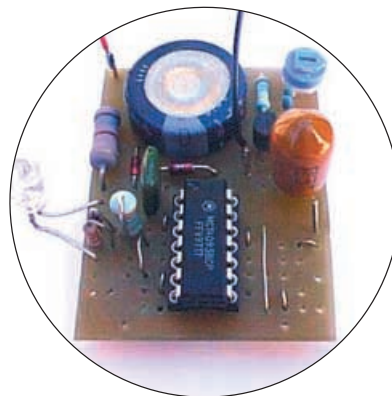


Fig.4. Delayed transition from output high to output low.

discharged. This sequence begins again once the capacitor’s charge has dropped to one third of the supply voltage.

Armed with this knowledge, you should be able to understand (almost!) all the workings of the projects in this series and even develop further circuits of your own.

Next month: *L.E.D. Flasher, Double Door-Buzzer, and Single Door-Buzzer.*



READOUT

E-mail: editorial@epemag.wimborne.co.uk

John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

WIN A DIGITAL MULTIMETER

A 3½ digit pocket-sized I.c.d. multimeter which measures a.c. and d.c. voltage, d.c. current and resistance. It can also test diodes and bipolar transistors.

Every month we will give a Digital Multimeter to the author of the best *Readout* letter.



★ LETTER OF THE MONTH ★

DOCTOR'S ORDERS

Dear EPE,

Just to let you know that your magazine has been a saviour to me. Having subscribed to it for a number of years without embarking on any of the fine constructional projects published because of pressure of work, I dropped the subscription last year, definitely a mistake on my part!

Some five months ago, I was signed off from work so the medical profession could investigate my ongoing health problem. However, instead of sitting around, doing nowt, I started to browse my old copies of *EPE* and my eye was taken by a number of articles which I could get stuck into and time would pass by in productive mode.

I also decided that learning QBASIC would enhance my understanding of *Toolkit Mk2* and

programming of the PIC16F877. As a result, the last several weeks has proved to be very interesting indeed, my Wife has become a Computer/Electronics Widow and I have built my own skeleton version of the *TK* software and successfully Programmed a PIC16F877 with TKTEST4.

Next step is to get hold of a Graphic LCD and continue with the Feb '01 supplement.

I have renewed my subscription and look forward to further interesting projects, especially *TK Mk3*, to keep me going. *EPE* has saved me from boredom and for that I thank all your staff and wish them well for the future.

Nick Biggs, via the Net

Welcome back Nick. We wish you every success.

KEYPADS

Dear EPE,

I recently added a keypad interface to a 6502 note-collecting unit and found your *Using PICs and Keypads* article (Jan '01) very interesting although I had a sinking feeling when I noticed the extra resistors R1 to R4 (which I haven't used). However, my prototypes haven't blown the 74LS139 column driver, presumably because in normal use the keyboard is continuously scanned so that each column can only be short circuited for a short time.

In order to understand your routine I converted it into C, without global variables and with a multidimensional array, which makes converting row and column into the correct character more obvious. I used the CCS PCM compiler.

I have also read your *PIC V-Scope* article: it seems quite a slow scope: I wondered if it could be speeded up by running the PIC at its full 20MHz and using external ADCs on the pseudo data/address bus used by the RAM with a few of the spare port lines used as chip selects.

When reading this January's *Elektronics*, I noticed that one of the PIC projects was written in CVSAM which is a sort of macro assembler that maps standard type microprocessor mnemonics to PIC mnemonics. The web address is:

<http://www.tech-tools.com/cvaml6.htm>.

Alan Bradley, via the Net

Thanks for your interesting comments Alan. Yes, PIC V-Scope could run faster as you suggest, although it fulfils my original intentions for a really simple PIC-only unit. One day I might try the route you suggest, with enough encouragement from you all. Do you all want one?

Thanks for the useful Elektron info, too. (In case readers wonder about us acknowledging the existence of other mags, we are quite happy to mention them when appropriate, in the belief that the market benefits by having several rival publications devoted to the same subject. We are the best, though!)

DOOR BELL SLAVE

Dear EPE,

I see *IU* is suffering from a lack of material (*Editorial*, Mar '01). Whilst I am unable to submit any circuits, I suggest that a reader might consider offering a solution to the following problem:

I have a wireless chime with a range of 30 metres, which is three metres too short to reach my workshop from the front door. How can I use a second unit as a "slave-relay" to increase the range?

The *Door Bell Extender* of March '01 is unsuitable as the earthing system in Ireland is different to that in the UK. In Ireland an earth does not come in with the supply, rather the Neutral is earthed by taking a wire back out and driving an earth rod into the ground.

**M. Guthrie,
Loughrea,
Co. Galway, Ireland**

Well, anyone? (The colleague who suggested moving the house nearer the shed has been severely rebuked!)

YES TO USB

Dear EPE,

In response to *Readout* May '01, I think you should definitely look into using the USB ports on computers. I think they should be quite easy to use and there is plenty of info out there about them. Check the following website:

<http://www.lvr.com/usb.htm>

With their potential speed of 480Mb/s you could do an oscilloscope project, like the one in the May issue, but just using a fast ADC and the USB port then get the PC to do the rest... you could end up with very cheap single channel 50Msamples/sec scope!

**Matt Lee,
via the Net**

Thank you Matt. The LVR site is also useful for a whole raft of other info too, including Visual Basic subjects.

USING USB

Dear EPE,

I feel there should be more mention of USB with regards to the possibility of amateur constructors using it to interface with computers. I have a 300+ page document of the official USB V1.1 specification and after reading through it, there seem to be three points to consider:

1. Hardware/electrical: neither is much of a problem here, the connectors can be purchased, or taken from a cheap USB extension cable, and the interface circuit is no more than a few buffer gates and associated resistors and capacitors.

2. Interface signals: more complicated – USB has two modes of operation, high speed at 12MHz and low speed at 1.5MHz. While this low speed mode might just about be usable on fast PICs, I doubt 12MHz is achievable on even a 20MHz PIC. However, there is rumour that Microchip are planning a PIC with USB support.

The signal itself is not much more than a souped-up RS232 communication; it has start and stop bits, and the usual signals that an asynchronous communications protocol has. The communication uses an NRZI differential signal with bit stuffing after six non-changes.

However, USB is different to RS232 in one key aspect; it is a multi-connection protocol. Whereas RS232 only has to consider one channel of information, and so communicates individual characters, USB works by a different principle, similar to TCP/IP or other packet-switching networks.

Each USB device establishes a number of virtual pipes with the host controller (i.e. PC), and all communications occur through them. To send a packet requires quite a bit of processing, so perhaps more than one PIC is required, one to act as a special-purpose UART, and the other to provide the actual data. Note that allowance must be made for mixed byte lengths in a row as not all the USB message fields are eight bits long.

3. Software Drivers: the operating system does not give access to the USB port like it does to serial, but only to the end data used by these virtual device numbers. When the host controller detects a new device on the bus, it queries it for its device number (unique to model, for example, a particular make of USB mouse), and loads the appropriate driver. This driver is then allowed to communicate to the device which it knows only by the virtual port number.

**Paul Evans, 1st year Maths & Computing,
Cambridge, via the Net**

Many thanks Paul for your enlightening comments (and for the other helpful information in your E-mail, but which we do not have space to include).

SOLDERING QUESTIONS

Dear EPE,

I recently came across Alan Winstanley's very informative soldering/desoldering "tutorial" and have two questions. First, would there ever be any reason someone might choose a 25W iron over say a 50W iron? Many higher priced soldering stations seem to provide the option of choosing a lower wattage iron on even higher power stations, such as a 20W or 40W iron on an 80W station.

Your soldering tutorial seemed to explain that the power rating of the iron was primarily an indication of its resilience to heat loss when working on “larger jobs” or quickly working one joint after another. It confuses me that lower power irons can achieve the same temperature as the higher power irons.

My other question is regarding Weller soldering stations. The choice seems to become the WES50 running at about \$100 US and the WS80 at about twice that. The WS series offers a substantial amount of more features, but which I am unsure if I need. The former being a 50W station and the latter an 80W seems to be the only “issue” I can think of.

Can you offer guidance to someone who will solder quite regularly but does not need the exacting control of a high-priced iron. I consistently work with CMOS electronics.

Arthur W. Green, via the Net

Alan replies to Arthur:

It's true that irons will reach the same temperature (soldering stations have a variable control), but one with a higher wattage has more power (heat) in reserve. This only becomes apparent when soldering larger joints, or when performing many joints in rapid succession. Here's why . . .

The lower-wattage iron will struggle to keep heated up, with the result that heat can be drawn out of it faster than it can be replaced by the element. So the joints will not be formed correctly. At a minimum, the user must wait for the iron to regain its operating temperature in between making joints.

If you tried to solder a copper water heating cylinder with such an iron, the copper tank would draw out all the heat from the element, and the tip would never reach the melting point of solder. The tip would be stone cold.

A higher wattage (25W-40W) is able to keep heating the tip such that heat is replaced as quickly it's taken away by larger joints. It's a bit like a moving conveyor belt, with heat being pumped in at one end and taken out at the other. A higher wattage allows the conveyor belt to keep up!

On basic irons, the tip temperature is thermally balanced, and the iron is designed so that the element warms it up approximately as quickly as heat is lost to the ambient air. As I said in the guide, consider a higher wattage iron as more “unstoppable”.

A 25W iron is fine for general hobby use, a 40W temperature controlled iron includes a “thermostat” for closer temperature control and is a better bet.

Regarding your other question, a 50 watt iron should be more than enough, with ample in reserve for almost all routine soldering of discrete and integrated components. A temperature controlled soldering station would be ideal, if you can afford to spoil yourself then that is what I would buy. But it may be overkill, and you could instead practice your skill on a cheaper iron before deciding to upgrade.

A fixed temp-controlled iron will be fine though, and Weller have plenty of spares, tips, handles, etc. and are extremely popular. You won't go wrong with a Weller. Skilled engineers I know use a 40W Weller and are very happy. Here in the UK I'd expect to pay say £40 (\$60 US) for a good iron.

PIC PROGRAM EDITOR

Dear EPE,

I have just built the board for your *PIC Tutorial* (Mar-May '98) and have my first I.E.D.s flashing. What excitement! Having found a Windows editor called PFE by Allen Phillips that I prefer over the Microsoft one, I managed to get your program to use it instead.

I open PFE, edit or write a program and then launch your programmer from there, continually hopping between the two, but having to “re-maximise” each time. I read with interest that you will be making a Windows version. Maybe you can have your new programmer running from an

editor designed specifically with your projects in mind.

You are the leaders in this field and I have decided, after following your articles from way back when, that you are now the electronics “guru”, surpassing even Bob Grossblatt of *Radio Electronics* fame.

**Mike MacLeod,
Mossel Bay, South Africa, via the Net**

Flattery is always welcome! In fact, Mike, Toolkit for Windows (TK3) provides access to any text editor of the user's choice. We are aiming at publishing in the October '01 issue.

CLOCKING CLOCKS

Dear EPE,

Referring to Chris Betts' letter (*Synchronous Motors*, Readout Apr '01), some time ago I solved a similar problem by locking a 300Hz oscillator to the 50Hz UK mains supply. I then locked a 60Hz oscillator to this 300Hz source and fed the result through a small step-up transformer driven by a switching transistor. A second small transformer stepped down the 50Hz mains and a half-wave rectifier provided the d.c. power required. No crystals or stabilised supplies were needed, and the solution was cheap!

Les Williams, Stourport on Severn, Worcs

Interesting, thank you Les.

REVAMPING IDEAS

Dear EPE,

It is noticeable that old ideas get revamped every so often, mostly disguised by the use of a PIC or some other processor type device. I suppose there are only so many circuits to go around.

I have a large collection of older magazines, if I find a good circuit that can't be built as originally intended would it be possible to send in the idea for an updated article?

There are some ideas that are timeless in concept but require reworking to achieve a practical design – that is, finding updated devices or a new way to invent the wheel.

Ian Johnson, Kidderminster, Worcs

Yes, Ian, there are some basic concepts that deserve updating from time to time for the sake of those who have newly entered electronics or when more advanced techniques allow them to be implemented more simply.

If any reader has an idea which he would like to recommend as a possible EPE article we will be pleased to consider it. Whilst as a magazine we do not actually design circuits, we have many enterprising contributors who delight in plying their designing/authoring skills and who could well be interested to follow up suggestions.

PIC TRICKS

In response to my request in Readout May '01 for short snippets of interesting PIC codes, Harry Purves of Newcastle-upon-Tyne sent a lengthy E-mail about some definition tricks he finds useful. It is too long to quote in full but the summary is that he defines the Status flags and the actions to be taken following certain function tests (which can otherwise get him confused!). Examples are:

```
#define carry status,0
#define dcarry status,1
#define zero status,2
#define ifzero btfsz zero
#define ifnotzero btfsz zero
#define ifequal btfsz zero
#define ifnotequal btfsz zero
#define ifcarry btfsz carry
#define ifnotcarry btfsz carry
#define ifnegative btfsz carry
#define ifpositive btfsz carry
```

As an example of the use of the latter he quotes:

```
subwf count,w
ifpositive
```

```
goto positive_result
return
```

which causes a jump to the stated destination if indeed the result is positive.

He keeps the definitions in header files so that they are always available for each project by simply “including” them at the start of the source file. For example:

include “C:\Picprog\Projects\header\l6f84.h”

Thank you Harry for sharing this info with us.

BASIC IS EASIER

Dear EPE,

To add to the discussion as to which language to use, I speak from about 25 years experience as a computer hardware engineer. My excursions into programming have ranged intermittently from machine code (in binary, octal or hexadecimal as required), assembler of various varieties, Algol, Fortran and Basic etc. Whatever the merits of any of these for a particular task I can assure you that for *intermittent* use, M. Bradbury in the May issue is spot on. You cannot beat Basic for ease of re-learning.

Any language is relatively easy to use when you know how. The trouble is that if you go away and do something else for six months, it takes a long time to pick it up again. By far the easiest to pick up again is Basic in one of its various flavours.

In common with most of your readers, I suspect, while I am interested in PICs, their use and programming, it is not something that I do all the time. For instance, I followed your *PIC Tutorial* without difficulty and built and used the *Toolkit MkI* programmer. However, now I am considering a new project and find that I have forgotten it all so I will have to re-learn it. The easy bit will be relearning any Basic required.

Roger Warrington, via the Net

Indeed so Roger. As familiar as I am with several programming languages, if I have a difficult bit of logical code to write, I will often first write it in Basic, and translate that to the equivalent code in PIC or whatever.

One big advantage of Basic is that it can have intercepts easily placed at strategic points at which intermediate data can be displayed on screen, and for new variables and sub-routines to be temporarily introduced without having to recompile to machine code. This makes tricky development much easier.

ELECTRONICS TUTORIALS

Dear EPE,

I have recently started buying *EPE* again regularly. I like *Circuit Surgery*, *Ingenuity Unlimited*, *Network*, *New Technology Update* and of course series such as *Teach-In* and the specials like the recent *Schmitt Trigger* series. I think I ought to do something with PICs. Just a suspicion . . .

I also check the web for info and interest from time to time. One thing that I have come across, amongst the many “home pages” that amateur radio and electronics hobbyists publish is the one produced by Ian Purdy (VK2TIP) from Australia. I think it's a good source of info and practical examples for anybody new or old to radio and electronics.

You need to have a look at the extent of the site to gauge how much effort he puts in, and I think it's worth a “plug” in *EPE*. I have absolutely nothing to do with Ian in a business or personal sense, apart from admiring what he's got on his site. As a pensioner and a radio amateur, I regard what he has done as an excellent job in propagating knowledge and interest in a fine hobby. His web address is:

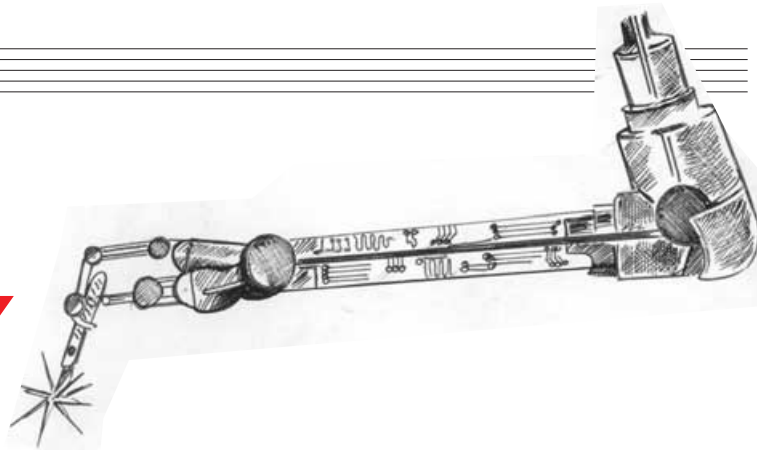
www.electronics-tutorials.com

Bill Jones, via the Net

Yes Bill, I've had a look at Ian's site, it does seem good and I commend it to other readers. I have also added it to TK3's list of recommended sites. Thank you for all your kind comments.

CIRCUIT SURGERY

ALAN WINSTANLEY
and IAN BELL



Logic families and component voltage ratings come under scrutiny in our regular column answering readers' problems.

Keep it in the logic family

OUR thanks to reader **Richard Black** who E-mailed us about logic families:

After four years, I've suddenly found the time to take up electronics as a hobby again. On designing my first project I have discovered that I can't remember the differences between 74LS, 74HC and 4000 series ICs.

For example, what's the difference between the following: 7400 quad 2-input NAND, 74HC00 quad 2-input NAND, 74HCT00 quad 2-input NAND, 74LS00 quad 2-input NAND? Hope this isn't a daft question!

This is not a daft question at all – there is a bewildering number of “logic families”, i.e. types of circuitry and technology for implementing discrete digital systems. The first commercially available logic family was resistor-transistor logic (RTL), introduced in 1962. This was followed by diode-transistor logic (DTL) and then the transistor-transistor logic (TTL) of the classic 7400 series. All these are based on the bipolar junction transistor (bjt), with TTL using a “multiple emitter” transistor at logic gate inputs.

New versions of TTL have continued to be introduced which provide higher operating speed and/or lower power dissipation, for example Advanced Schottky TTL (ASTTL). Another type of bipolar logic is

Emitter-Coupled Logic (ECL) which provides a very high speed of operation.

Going MOS

In addition to these bipolar logic families, there are a number of MOSFET-based families. MOS logic may be implemented using *n*-type or *p*-type transistors alone (NMOS and PMOS), or both together (CMOS). NMOS provides higher performance than PMOS, but the advantages of CMOS mean that most MOS logic is now CMOS.

The classic CMOS logic family is the 4000 series, but just to confuse you even more, CMOS versions of the “TTL” 7400 series are also available (74HC00 and others). MOS and bipolar transistors can be used together to exploit the advantages of both, in Bi-CMOS, the 74ABTC series for instance.

CMOS 4000 series are susceptible to damage by static electricity (so handle with care), can operate on +3V to +15V supplies, and may behave unpredictably if inputs are left unconnected. Compare this with the original 7400 and other TTL series, which must have a supply of +5V ($\pm 0.5V$), are not static sensitive and have inputs that behave as logic 1 when left floating.

The 4000 series provides some multiplexers that can be used for switching and selecting analogue signals, but there are no analogue functions in the TTL 7400 series. Other series have different properties, for example 74LVC00 is a CMOS series operating on a 3-3V supply. Not all functions are available in all families though.

When designing with discrete logic it is important to be aware of the general differences in the behaviour of the different logic types (CMOS, TTL, ECL etc) and the individual specifications of the logic family you are using, such as the allowable supply voltage range, power consumption, and typical propagation delays. The “maximum fanout”, logic levels and drive currents are also worth checking. Maximum fanout is the number of inputs that a single output will drive and still give good logic levels.

Variation in logic levels and drive capabilities mean that you cannot necessarily connect the output from a device from one logic family, directly to the input of one from a different family. Some conversion devices are available to help with this problem. The ability of logic outputs to drive non-logic loads such as l.e.d.s. also varies between families.

To find out these details consult a data-book for the series, or a datasheet for one of the devices. If you do a lot of logic design it is a good idea to get hold of the appropriate manufacturers' data books or CD-ROMs as these contain sections covering the general characteristics of the devices in the series and design guidelines, as well as all the individual datasheets. This data is also available on-line from the semiconductor manufacturers' web sites.

A summary of just some of the 74 series variations is shown in Table 1. Often you will be able to manage with LS or HCT families for most project or experimental work. These parts are widely available by mail order from all the usual vendors. *I.M.B.*

Capacitors, Resistors and Voltages

I need to get some parts for a schematic which requires a 9V battery. What voltage should the resistors and capacitors be? Some of the parts sold have a rating of 100V, I guess I can't use those, or can I? Thanks, Ilya, via E-mail.

There's no problem using components that have a higher voltage rating in your 9V circuit. The value is simply the maximum voltage rating they can sustain

Table 1: Some 74 series variations

7400	Standard bipolar TTL, the originals!
74LS00	Early TTL “low-power Schottky” improvement over basic 7400 series
74ALS00	Higher speed, lower power TTL than LS
74F00	High speed “Fast” TTL improvement on LS
74HCT	Direct CMOS equivalents to LSTTL. +4.5V to +5.5V supply
74AC00	CMOS, with CMOS logic levels
74ACT00	CMOS, with TTL logic levels
74FCT00	CMOS. Low power than 74F, by virtue of CMOS technology
74HC00	Basic high speed CMOS, similar to TTL. 2V to 6V supply
74LV00	CMOS 3-3V supply
74LVC00	CMOS 3-3V supply, faster, improved output over LV.



Example of a 4072 CMOS digital i.c.

without damage. Polyester or ceramic capacitors have typical voltage ratings of 63V, 100V, 200V or even 500V or more. Any of these values can be used in your 9V circuit, no problem at all except for physical size, perhaps.

Some types, notably polypropylene capacitors, are specially designed for higher voltages or for direct use with mains a.c. voltages, when it is critical that the correct voltage rating is observed. Furthermore, in the UK capacitors which are intended for mains voltage use are further classified according to their ability to withstand peak voltages.

Devices with an "X" class rating can be connected directly across the mains, e.g. as a suppressor. According to the handy reference book *Newnes Electronics Toolkit* by Geoff Phillips (ISBN 0-7506-0929X) a Class X1 type can withstand transients (spikes) exceeding 1.2kV; a Class X2 can cope with



Example of a high voltage polypropylene capacitor.

transients less than or equal to 1.2kV.

The book also explains that a Class Y capacitor is intended for connection as a suppressor to ground (earth). These are specially designated for earthing connections as they have a guaranteed maximum leakage current, so that no electric shock hazard will arise. Such aspects are of critical importance in medical equipment



Electrolytic capacitors show their maximum working voltage rating which should not be exceeded.

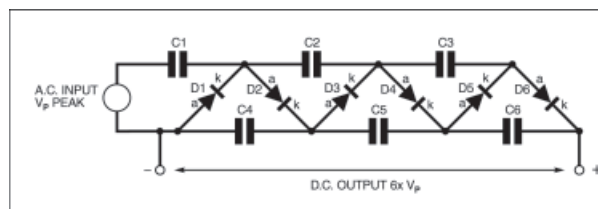
applications.

One component which does require special consideration is the polarised electrolytic capacitor. For general electronic circuits, these are seldom seen with voltages higher than 63V or 100V d.c. It is perfectly safe to use a higher-voltage rated capacitor in a low voltage circuit; it is however very unwise to greatly exceed the capacitor's voltage rating, and it can be dangerous to reverse-polarise an electrolytic by a substantial amount for any length of time.

Resistor Voltages

Turning to resistor values, again there would be no problem using any type in the reader's 9V circuit. For example, the popular Philips CR25 is rated at 250V which would be just fine for the project.

Fig. 1. Cockroft-Walton voltage multiplier producing six times the a.c. peak input voltage.



Sometimes you *do* need to pay more attention to resistor voltages though – in fact, resistor voltage ratings can be an area of some confusion.

The Philips product catalogue specifies the voltage rating as " U_{max} " (V_{max}) which we take to mean the maximum voltage across the resistor. However some sources mention "250V r.m.s." for this value, which implies a peak voltage rating of more like 350V. There seem to be no hard and fast rules concerning whether maximum voltages are r.m.s. or peak, so this aspect would need confirming where necessary. Sometimes, several resistors are wired in series just to ensure that individual voltage ratings are not exceeded.

There are several interesting aspects of resistor ratings which are worth bearing in mind. Using the formula $P = V^2/R$, placing 500V across a 1M resistor means that the resistor would dissipate 0.25Watts. Whilst this is within the power rating of a typical small carbon film resistor, it would exceed typical voltage ratings. Manufacturers sometimes quote a voltage rating and a "maximum overload voltage" or even a parameter known as the "limiting element voltage" that you see in many data sheets.

For example, a data sheet for carbon resistors, downloaded from the web site of manufacturer Kamaya Ohm, defines the rated voltage as:

Rated voltage ($V_{d.c.}$ or a.c. r.m.s.) =

$$\sqrt{(\text{Rated Dissipation}) \times (\text{Rated Resistance})}$$

Here the *rated voltage* is clearly derived from the power rating using the formula $P = V^2/R$. But in case you think you can apply any voltage across the resistor provided the power dissipation is not exceeded, there are more factors to bear in mind!

On the Limits

Another resistor voltage rating sometimes quoted is the limiting element voltage which, Kamaya states, can only be applied to resistors where the resistance value is equal to or higher than the "critical resistance value". I presume this latter term is the minimum resistor value permissible to ensure that the resistor's power rating is not exceeded at any given voltage; so at 250V d.c. voltage drop, the "critical resistance value" of a 0.25W resistor must be 250 kilohms or more; at 9V d.c. it would be just 330 ohms.

Depending on the resistor type, the limiting element voltage is typically 200V to 350V d.c. or V a.c. r.m.s. All resistors have a maximum overload voltage, but if the limiting element voltage is quoted instead, you can take this to mean the maximum voltage allowed across the resistor provided its power rating is not exceeded.

Note that if the overload voltage is exceeded then the resistor's insulation may break down, even if the resistor is dissipating hardly any power. A.R.W.

More on Multipliers

Gregory O'Kelly E-mailed in response our article on voltage multipliers in January 2001:

In your January 2001 edition, on page 36, you show a voltage multiplier that allegedly increases the voltage by a multiple of six of peak input voltage. I find that it is more like 2 to the sixth power, with each electrode acting almost like a doubler. I have hooked this up to the output from a 555 timer in an attempt to get something like an ignition coil, but the current flow is extremely low.

I want to use the pulsed d.c. to produce electrochemical pulses, and I need greater current flow. Could you tell me how to go about doing this? Do I increase the capacitance? Since I want merely to multiply the output voltage from the 555 timer by a multiple of 6 or eight, not 64, should I just use three capacitors of a high faradic rating?

We repeat the schematic to which Gregory refers in Fig. 1. Although the circuit is called a voltage "multiplier" the action is really additive. The capacitors add up the peak voltage of the a.c. waveform. One stage of the multiplier does not multiply the output from the previous stage – it just adds more multiples of the input voltage.

We mentioned in the original article that the Cockroft-Walton voltage multiplier did not readily provide high current outputs, and that the voltage would tend to drop in response to sudden changes in loading. Unfortunately, the circuit is not good at high currents because it takes several a.c. cycles to recharge the multiplier, also the capacitors are effectively in series, reducing their effective capacitance. Thus the output ripple is high and the regulation is poor.

In order to get a higher current output you first need to make sure that the source (a.c. input) is capable of supplying the required current at the low voltage end of the multiplier. This may include some demanding current transients to charge the capacitors quickly and we strongly doubt that a simple 555 would be up to the job.

Using high quality, suitable components, and high quality construction will help reduce losses in the circuit. Larger capacitors will allow the circuit to provide larger transient energy to the output, but if this is to be sustained the source has to be up to the job of constantly "recharging" the multiplier. Furthermore, high current demand from the load may still result in large voltage drops and high ripple.

We're not sure there is a simple solution for what you're trying to achieve, namely a source of high voltage, high current pulses for (we guess) laboratory experiments. I.M.B.

THE WORLD OF PLCs

OWEN BISHOP



In industrial manufacturing processes, Programmable Logic Controllers (PLCs) offer many advantages over standard digital logic or computer control.

IN EPE June 2001, we looked at how electronics played an important role at Jodrell Bank. That article was the first of an occasional series looking at how electronics is used to control various industrial and research applications.

During the industrial visits made for this series it has become clear that PLCs, or Programmable Logic Controllers to give them their full name, are currently the most popular devices used for electronic control. In this article we look at PLCs in general and describe a number of examples of their application in various industries.

RELAY LOGIC

Before we consider PLCs, it is interesting to look at two earlier but related techniques, the older of which is relay logic control. In many instances this gave way to hardwired logic integrated circuit control. Relay logic is still used by several companies for controlling processes that do not demand the more complex programming achievable with PLCs.

The simple example shown in Fig.1 (see also Panel 1) shows only the relay contacts, and omits the circuits associated with the various sensors which provide input to the system. It also omits any interfacing there might be to deliver sufficient electrical power to the solenoids or motor.

Although a well-designed and proven relay logic system can give years of trouble-free service, it has several drawbacks.

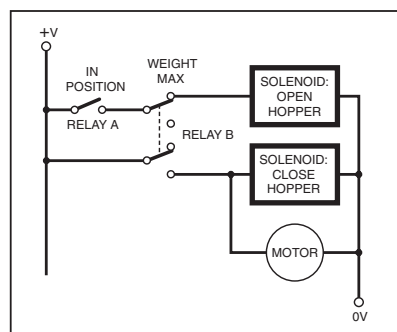


Fig.1. Relay logic for filling a packet with grated cheese.



Automatic cheese packaging line at Glanbia Foods Ltd.

One of these is that relays take up a lot of board space and even a relatively simple process such as filling a packet with cheese requires many relays. Partly compensating for this is the advantage that, given the schematic, it is easy to understand how it works.

A third point about relay logic is that it is hard-wired. This makes it easy for an engineer to test its action with a multi-meter and to service it and make any adjustments that may be necessary. But it takes appreciable time to design, assemble and wire up the board. Once built, it may be very inconvenient and costly to alter it to correct errors in design or to modify

or extend its action. Very often the easiest solution is to scrap the entire board and start again.

LOGIC GATES

Hardwired logic control makes use of the large range of logic i.c.s of the TTL, CMOS and other families. The function of Fig.1 can be performed by logic gate i.c.s,

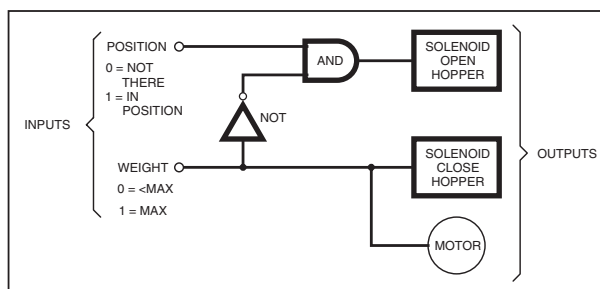


Fig.2. A logic gate circuit with the same function as Fig.1.

as in Fig.2, supplemented by interfacing not shown.

One obvious advantage of i.c.s is that they take up far less board space and require far less power to drive them. But, because they are hardwired, any alterations to the existing circuit can be difficult or even impossible. Furthermore, the average electrical (as opposed to electronic) engineer is likely to find them more difficult to install and service.

This brings us to PLCs, which are intended to provide a wide range of control functions based on (though not restricted to) the principles of relay logic.

PLC SYSTEMS

The main parts of a PLC system are illustrated in Fig.3 and, as an example, the photograph below shows the contents of a PLC cabinet that controls one of the packaging lines at Glanbia Foods Ltd.

At the centre of the system is a controller unit. This is where all the logical operations take place and where programs and data are stored. The controller is the large white box at top left. To its right is another smaller box, which is an extension unit to allow more inputs and outputs to be connected.

Although the controller is based on a CPU, the manufacturers play down its importance. In the world of PLCs there seems to be no equivalent of the "Intel Inside" sticker found on so many PCs.

Looking through the literature and data sheets one rarely comes across any mention of what kind of i.c. is doing all the work. Instead the specification concentrates on how many inputs and outputs the controller has, the maximum number of steps in its program and the time taken to execute a single step.

These facts are the main ones of interest to an engineer designing and building a PLC system. For the rest, the system is regarded as a "black box".

PLC PROGRAMMING

The inputs and outputs (I/O) of a PLC are much more numerous than those of an

PANEL 1. Relay Logic

A simplified control system for filling packets with grated cheese is shown in Fig.1. The cheese is supplied by a hopper that can be opened or closed by solenoids that operate in opposite directions. A sensor (perhaps optical) detects when a packet is in position to receive the cheese. A signal from the sensor energises the coil of relay A if a packet is in position. The packet is on a platform (a segment of a conveyor belt) supported by a load cell, which measures the weight of the packet and the cheese, if any, it contains.

A signal from the load cell energises relay B if the weight is at its maximum value (packet full). Relay B has two contacts, the upper one being closed when the packet is not full. So, a solenoid opens the hopper if the packet is in position AND the packet is NOT full.

The lower part of the circuit controls what happens when the packet becomes full. Relay B is energised, turning off the "open" solenoid and turning on the "close" solenoid. This stops the flow of cheese into the packet. The change in relay B also starts the motor that moves the conveyor belt to take away the full packet and replace it with an empty one.

The circuit is a gross over-simplification of what is usually needed to control such an operation. There would normally be sensors such as microswitches to confirm that the hopper is actually open, or closed. Input from these sensors would be used to activate additional relays to be wired in series with relays A and B.

There would be sensors to confirm that the packet had actually been taken away. There would also be a delay between closing the hopper and moving the packet. A relay with a non-ferrous slug on its core could be used to produce such a delay.

ordinary desktop computer. A PLC does not necessarily have a keyboard, a disk drive or a monitor but it may have several hundred inputs and outputs. In the PLC world, I/O is of supreme importance.

The I/O is in the lower section of the photograph below and the leads connecting this to the control unit can be seen.

Since the system does not usually have a keyboard or monitor, it is normally programmed by attaching a special programmer to it. This is needed only when setting up the system or occasionally when making changes to its operating routines.

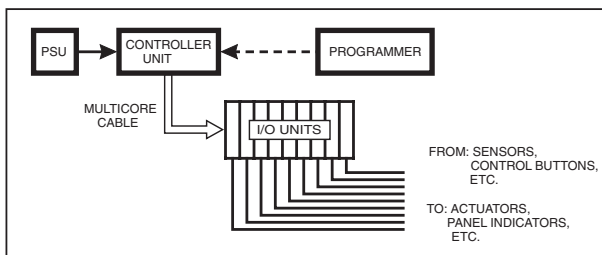
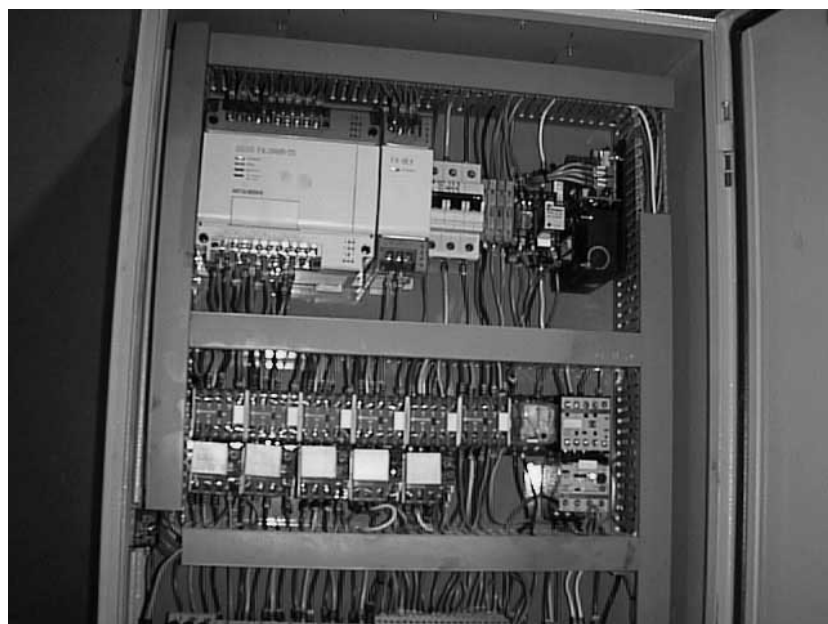


Fig.3. The essentials of a PLC system.



Detail of the PLC system at Glanbia Foods Ltd.

Some manufacturers produce a special purpose programming computer, similar to a PC, but often having a keyboard with keys dedicated to keying in PLC programs. Other systems use a regular desktop or laptop PC running specialised programming software.

A PLC system usually has its own power supply, separate from the supply to the sensors and actuators of the system. This prevents electrical noise from passing into and disrupting the action of the processor. Most PLC units operate on 24V d.c.

PLC units are manufactured by a number of specialist companies who produce the controllers, compatible I/O units, PSUs and other units with a wide range of specifications so that a designer can pick out just that combination of units which best suits the requirements of the plant.

It is also a feature of PLC systems that the individual I/O units are relatively inexpensive so that a few additional ones can be included in the system when it is first put together. This allows for subsequent expansion to cope with initial design faults, afterthoughts, process modifications and expansion. In this way PLCs are superior to hard-wired relay and logic systems.

The advantages of PLCs have become so widely appreciated that a number of manufacturers are now producing PLC systems suited for small-scale control such as thermostat and door opening systems. It is even suggested that the model railway enthusiast could find many ways of using these small-scale PLCs.

INPUT/OUTPUT OPTIONS

An I/O device usually consists of a rack-mounted circuit card bearing a number of identical interface circuits. Each card has its address in the memory map of the controller, and on that card there are usually several (typically eight) individually addressable I/O circuits.

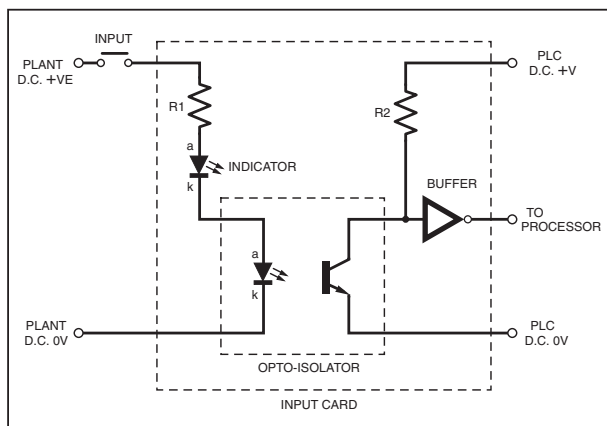


Fig.4. A d.c. input card, one channel.

In Fig.4 is shown one circuit (or channel) on a typical d.c. input card. This is intended to receive a d.c. signal (usually a logic high or low) from the plant and to send an identical signal on to the processor. The plant and processor do not necessarily operate on the same d.c. levels but this is taken care of in the circuitry.

The circuit includes an opto-isolator to protect the processor from any high voltages that may find their way to the card from the plant. There is usually an indicator l.e.d. on the card (often a row of l.e.d.s on the edge of the card, one for each channel). The output side of the card is powered from the controller's d.c. supply.

Usually the input side of a system is made up of a mix of d.c. and a.c. cards. The system designer can select from various type of card of either sort, adding a few spares in case of a change of design at a later stage.

A.C. INTERFACING

The typical a.c. input card circuit in Fig.5 has a full-wave bridge rectifier. An indicator lamp (not an l.e.d.) across the input connections lights when a signal is being received (the a.c. signal is either on or off).

The rectified signal goes to an opto-isolator to protect the system from excess voltages. Since the input signal is often at mains voltage this precaution is essential. Beyond the opto-isolator the circuit is powered from the system power supply and a buffer sends a logic-level replica of the input signal to the processor.

Output cards also incorporate opto-isolators. In a typical d.c. output card (Fig.6) logic-level signals from the processor are sent to a transistor which switches the current through the photodiode of the opto-isolator. The phototransistor is in the base circuit of a power transistor which has its collector connected to the plant d.c. supply. This may often be at 24V d.c.

The load is in the transistor's collector circuit. Connected across the load is an indicator l.e.d. located on the card to show the state of the output. Also there is a diode to protect the circuit from the voltage spikes that occur if the load is inductive, as it often is, for solenoids and motors are very common actuators in industrial systems.

As an alternative to the transistor output of the d.c. card, some types of card have relay outputs. The coil of the relay replaces the load shown in Fig.6. It can be situated on the card and powered from the system

supply. Using a relay means that a wide range of plant voltages, d.c. or a.c., can be used to drive the load.

In an a.c. output card, useful for controlling motors, the plant a.c. is rectified to provide a d.c. potential across the phototransistor of the opto-isolator (Fig.7). When a signal is present, the phototransistor conducts and this produces a pulse to trigger the triac. The triac then conducts, and an alternating

current passes through the indicator lamp and the load.

Most cards deal with digital signals, those that are on or off, high or low. There are also cards for analogue signals, often incorporating analogue-to-digital converters for converting analogue input to digital form to send to the processor.

PROGRAM OPERATION

Apart from the read only memory (ROM) used for storing the operating system, the memory map includes the regions shown in Fig.8. The major part of this is PROM (programmable ROM), used for storing the program fed into it by the programming computer.

The PROM may extend to only a few kilobytes, which is sufficient for storing

the program steps that the controller requires. In addition, there is an area of random access memory (RAM).

The way in which a typical PLC operates its program is usually very different from the operation of a PC programmed in machine code or one of the high-level languages. In a typical PC program, the processor starts at the beginning, after which it may jump about indefinitely from one routine to another, depending on the input (from its keyboard, disk drives and elsewhere) that it receives at various stages.

It skips around the program from routine to routine, sometimes waiting for input and at other times producing output (continually updating the monitor, for example, or sending data to a modem). There may be some routines (such as updating the monitor, or waiting for input from the keyboard) that it returns to frequently. It may visit these routines several times a second. Other routines may be run very rarely, perhaps only when something goes wrong.

PLC SCANNING

While some of the more sophisticated PLCs do allow for conditional jumps and other features commonly available in PC programs, a typical PLC program is simply a series of steps taken in order from beginning to end, and repeated from beginning to end for as long as the PLC is operating. This is called scanning the program and a scan takes about 2ms to 5ms per kilobyte of program, depending on the processor.

In a typical control system a scan takes between 10ms and 50ms, depending upon the number of steps in the program. Before

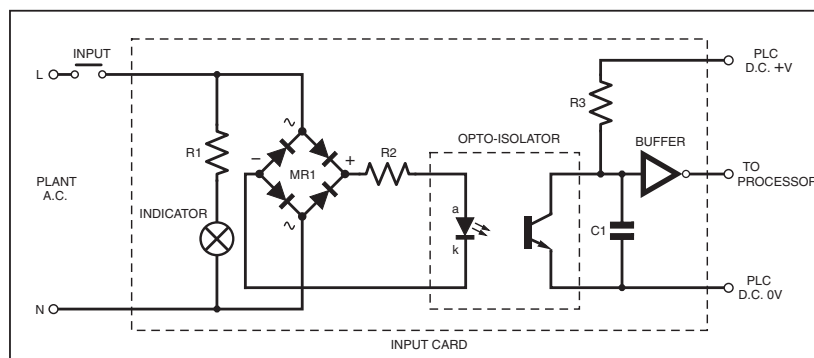


Fig.5. An a.c. input card, one channel.

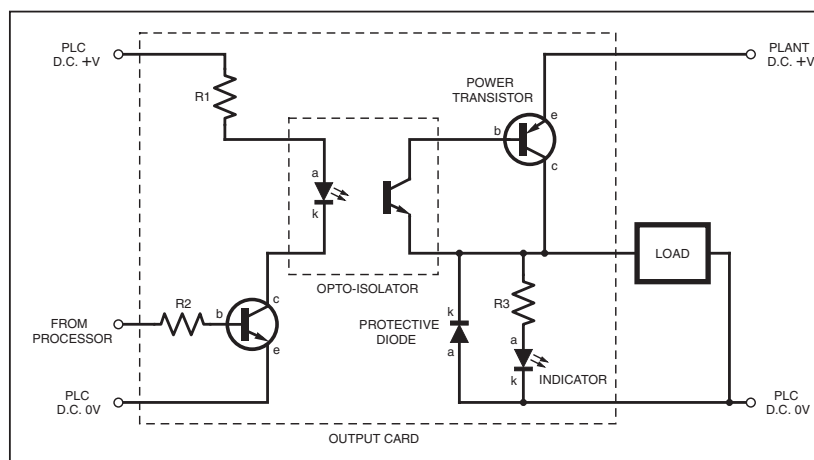


Fig.6. A d.c. output card with transistor-controlled output, one channel.

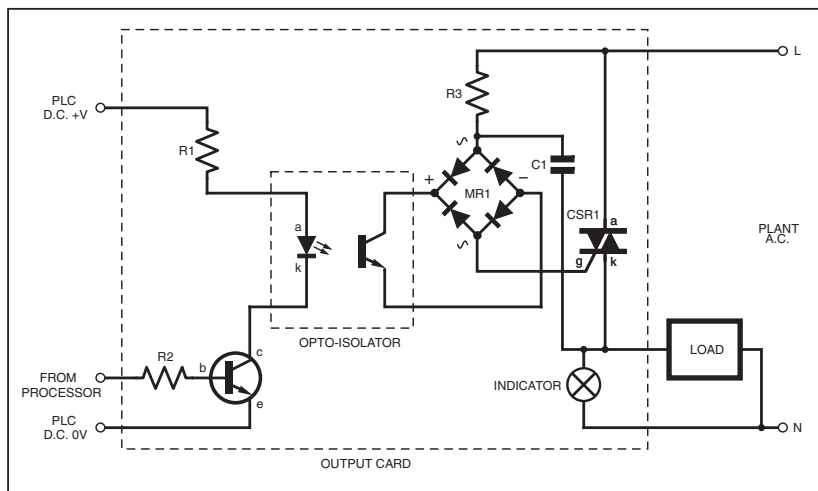


Fig.7. An a.c. output card with triac-controlled output, one channel.

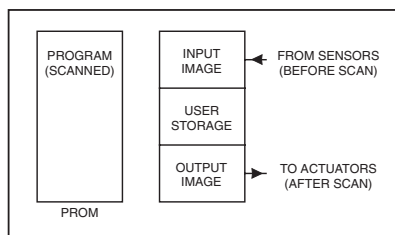


Fig.8. A map of the memory of a typical controller.

each scan, the processor reads in the state of all the sensors in the system. The data is stored in the area of RAM known as the input image, either as single bits (flags) or as analogue data in digital form.

Then the scan begins, using the recently acquired data of the input image. Decisions are taken and, if there are any changes to be made in the operation of the actuators, the control signals to be sent to the actuators are stored in RAM as the output image.

Signals are not actually sent to the actuators until the scan is complete. The remaining area of memory is used for temporary storage of intermediate data produced by calculations.

Once the scan is finished, the actuators are turned on or off according to data now present in the output image. This almost inevitably produces changes in the state of the system and these changes affect the sensors. Data is read from the sensors, stored as the input image and the next scan begins.

In this way the state of the system is read every few tens of milliseconds and appropriate action is taken. This gives a degree of control sufficiently tight for most industrial processes.

PROGRAMMING TECHNIQUES

There are three techniques for programming the PLC, of which one method appears to be far more popular than the others. This is known as "ladder logic" and derives its form from the relay logic used in the earliest control systems. It is a way of setting up a virtual relay system, without the bulky, space-consuming relays and the more-or-less permanent hard wiring.

Being based on the principles of relays means that the system can be understood (and therefore maintained) without the

need for a specialist electronic engineer. Returning to the examples of Fig.2 and Fig.3, the equivalent in ladder logic is shown in Fig.9, which represents the controls for filling a packet with a quantity of (in this instance) grated cheese.

In programming the system, a diagram such as this is drawn on the screen of the programmer or PC, the software converts this to the equivalent machine code, which is then downloaded into the PROM of the controller.

The symbols used in this diagram are derived from the symbols used in the USA for representing relays in schematics. A relay with normally-open contacts looks rather like the symbol for a capacitor.

The relay contacts are open until the packet is in position ready for filling. When the sensor detects that the packet is in position, the corresponding bit in the input image is set to logic 1. The slanting line across the next symbol in the top row of the diagram indicates normally-closed contacts. The contacts are closed unless the given condition is true. The "weight" bit in RAM stays at logic 0 until the packet reaches the required weight.

Viewing the diagram as a pair of relay contacts in series, a current flows from the left through the two pairs of contacts and activates the "open hopper" solenoid when both relays are closed. That is, when the packet is in position and it is *not* full.

During a program scan the processor reads the state of the two bits and, if one is logic 1 and the other is logic 0 it stores an

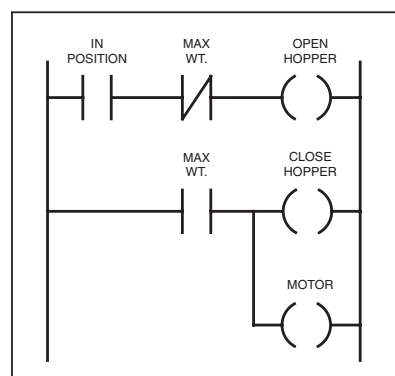


Fig.9. The equivalent of Fig.2 and Fig.3 in ladder logic.

"open hopper" bit in the output image. At the end of the scan an output is sent to the solenoid to activate it (or continue its state of activation), to keep the hopper open, delivering grated cheese to the packet.

The controller then scans to the second row of the program. Here the position of the packet is not important. If the packet has reached full weight, the output image must be changed to switch on the solenoid to close the hopper, and to start the motor to carry the packet away to be sealed. In this row the processor reads the weight bit again and, if it is logic 1, sets the bits to initiate appropriate action.

LADDER LOGIC

The schematic in Fig.9 illustrates only two steps in a program that might be 100 or more steps long. The complete program has vertical lines down each side, cross-connected by the row of symbols describing the logic. The appearance of the diagram of a complete program strongly resembles a ladder, which is why this form of representation has become known as ladder logic.

When we examine such programs it becomes obvious that even an apparently simple task requires a considerable number of inputs and outputs, perhaps several hundred on one machine.

Most systems suitable for controlling with PLCs also provide for the program to be entered as a drawing of a logical system. Here the programming is similar to that of the earlier control systems based on TTL or CMOS i.c.s. Logic symbols such as AND and OR gates are assembled on the screen of the programmer and connected by "wires". Then the software generates the corresponding machine code to be downloaded into PROM.

A third method of programming a PLC is by a text-only statement list. The logic of the system is keyed in, in standardised form, as a table of instructions to the processor.

The ladder logic described so far provides for logical operations such as AND (relays in series on a single rung), and OR (relays in parallel on branching rungs). The use of normally-closed relays introduces NOT, which provides for NAND and NOR operations.

Even when programming with ladder logic it is possible in the more advanced PLC systems to call on routines which provide the equivalent of flip-flops, counters and timers.

PLCs IN ACTION

To illustrate the versatility of PLCs this article concludes with a few examples taken from Glanvia's plant.

The photograph on the next page shows a section of the belt that carries packages of cheese from the wrapping section, which is off to the left of the photograph.

The package then passes on to a short length of belt, on a platform that is mounted on a load cell. This weighs the package as it passes across the section. Although one associates load cells with weighing massive objects such as fully-laden trucks, sensitive load cells are frequently used in packaging plants for objects weighing only a few hundred grammes.

Readout of the weight takes only a fraction of a second and is displayed on the

control panel. If the weight is outside the preset limits the next section of the belt tips downward, as shown in the photograph (below), and the rejected package falls into a receptacle below the line.

When a package of acceptable weight comes along, it continues along the main line to the right, where a vendor's label is printed with its weight and is applied to the package. The system also calculates the price of the piece and prints this on the label together with the bar code.

All this is done within a fraction of a second as the packages stream along the production line. The system keeps a full record of the number of packages passed and also the number rejected for being over or under weight.

SAFETY

Food safety is of paramount importance so special precautions are taken to detect metallic objects that might be embedded in the cut blocks of cheese. At one point there is a large coil around the conveyor belt and an oscillating signal is applied to this coil. Close above the line is an inductive proximity detector. This consists of a core wound with a coil and connected to a frequency-sensitive circuit.

If there is any metal object in the cheese there is a phase delay which is detected by the circuit. The PLC registers this change. The timing of the program is such that just as that block reaches a point 40cm further along the line, a rejection lever is actuated to push the block off the line. Alternatively, a photo-reflective detector further along the line may detect the arrival of the suspect block and operate the reject arm.

SIMPLICITY PAYS

The process is simple and well illustrates the nature of most applications of PLCs. Textbooks on electronic control systems lay great emphasis on negative feedback, proportional control, integral control and other sophisticated aspects of control systems, but these do not feature in the majority of practical systems.



Cheese weight monitoring system at Glanbia Foods Ltd.

PANEL 2. Chemical Plant Sensors

Most of the processing at chemical manufacturers Rhone-Poulenc Ltd. involves liquids, so the main measurements required are temperature, pressure, level and flow. The reactants are normally inside an enclosed system, but there must be points at which probes are allowed to enter the system. In the case of tanks, the probes are inserted through sealed openings at the top. This minimises leakage should the seal deteriorate.

Very often the activity at different parts of the system is monitored in more than one way using different types of sensor. One measurement is a back-up of the other and, if the two fail to agree, an alert is signalled on the control panel.

An ingenious way of measuring flow is the MicroMotion sensor, which depends on the detection of Coriolis forces. This is the force which makes the water spin in a clockwise direction as it drains from the bath (anti-clockwise in the Southern Hemisphere).

The fluid is made to flow in an omega-shaped tube and the force distorts the tube slightly. Distortion is measured using a strain gauge or an electromagnetic pickup and from this the rate of flow can be calculated. The liquid is completely enclosed in the tube and there are no vanes or other moving parts to be sealed in (and eventually leak).

Liquid level may be measured by a tuning fork level sensor (Fig.10). A crystal oscillator in the base of the fork vibrates the fork at 30kHz. However, when the tines of the fork are partly covered by liquid, this shifts the frequency of the system. The resulting frequency is measured and this is related to the liquid level.

Another method of level measurement involves capacitance. In effect the sensor of Fig.11 is a capacitor. If the liquid is an electrical conductor, the pin and the casing (plus liquid) act as plates and the PTFE sleeve is the dielectric. If the liquid is a non-conductor, the sleeving is omitted and the liquid acts as dielectric.

In either case, capacitance increases with liquid level. The sensing circuit measures the capacitance by measuring the frequency of an oscillating circuit containing the sensor. Changes of frequency are interpreted in terms of liquid level.

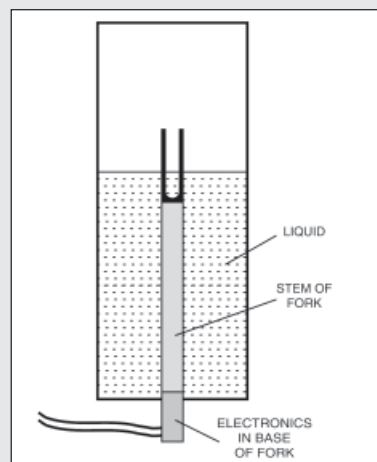


Fig.10. Tuning fork level sensor.

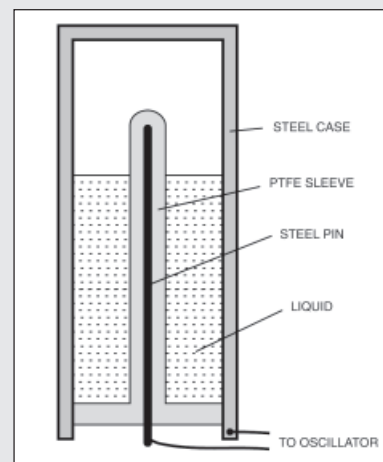


Fig.11. Capacitive level sensor.

It would be possible to devise a system by which the filling of, say, grated cheese bags would be monitored as it is occurring, bringing the weight up to the required level. Such a system would be more complicated, possibly slower, and certainly more expensive to build and maintain than the simple accept/reject system.

In practical and economic terms, the simpler (and cheaper) the system the better. This does not necessarily apply to all manufacturing processes, but it applies to most. It is cheaper to omit the fine adjustments and simply reject the occasional item that is out of range. On the shop floor, economics rules over control theory and PLCs are usually the best means for controlling systems at this level.

In practice, most control systems have a simple on-off binary nature. Only a small range of instructions is needed for such a system. The situation is akin to that which has led to the development of RISC (reduced instruction set) computers.

Research has shown that although a typical microprocessor may have several hundred instructions in its set, 80 per cent of a typical program makes use of only 20 per cent of the instructions. Now, microcontrollers are being manufactured

with as few as 30 instructions. This makes it very easy to learn the programming language.

SPECIAL PRECAUTIONS

Certain industries pose special problems that can be solved by PLCs, but which need attention to various precautions. The Rhone-Poulenc plant (see Panel 2), for example, manufactures agricultural products, such as herbicides, and intermediate products for the pharmaceutical industry.

It produces these chemicals on the large scale and their production often involves highly flammable liquids such as toluene, methanol and xylene. For this reason there must be no combustion or sparks in the areas where chemicals are processed and stored. Obviously there is no place for relays and other spark-producing equipment on the plant. There are risks when any electrical components are present, for a faulty device or cable might soon overheat to the point at which it could ignite a flammable vapour.

Each production rig has its own enclosed control room, keeping the operating staff well away from the scene of chemical reactions. Whereas the PLC cabinet is usually located beside the plant, mainly in order to keep electrical connections as short as possible, the PLCs at Rhone-Poulenc are situated in a special room adjacent to the control room.

The PLCs drive pneumatic actuators, so that communication between the PLC cabinets and the plant is exclusively by air lines. This eliminates the risk of fire or explosions caused by sparks or overheating.

The design philosophy of the system is that the consequences of failures are so potentially catastrophic that no chances can be taken. Consequently the sensors and actuators are all simple in principle and have proven reliability.

Also, there are many of them, monitoring every stage of production. This means that a system may have up to 1000 input/output connections and a correspondingly long (but well-tried and tested) program. The system designers have no intention of trying to lead the way in the chemical industry!

SUMMING UP

The industrial popularity of PLCs is attributable to their many advantageous features:

- At the design stage there is no need for a really detailed description of the proposed system. The size of the processor and the number of cards of each kind is easy to estimate within limits, allowing a little spare capacity for future modifications.

- At the construction stage the system is easily assembled from a wide range of standard units, most of which are relatively inexpensive.

- At the installation stage it is possible to make use of pre-built units to cover certain aspects of control.

- At the commissioning stage it is easy to modify the system if changes or extensions to the original design are thought necessary. As explained earlier, this is definitely not the case with relay logic and

PANEL 3. Resin Production using PLCs

Chipboard is made by mixing wood chips with a bonding resin, and rolling the mixture out into a sheet. At the Chirk works of Kronospan Ltd the resin is prepared in large kettles. Formerly, control of the process was wholly manual but, recently, it has been automated, using PLCs.

With either method of control the kettle is first loaded with formaldehyde and then urea is run in, using a screw feeder. The reaction is exothermic (generates heat), so the process can be started from cold, although materials may be warmed first to 60°C.

The heat produced by the reaction is such that the mixture has to be cooled by a cold water jacket around the kettle. Precise control is necessary at this stage because the reaction can soon run away, with the risk of an explosion. For this reason the reaction is carefully controlled and the temperature is never allowed to rise above 98°C.

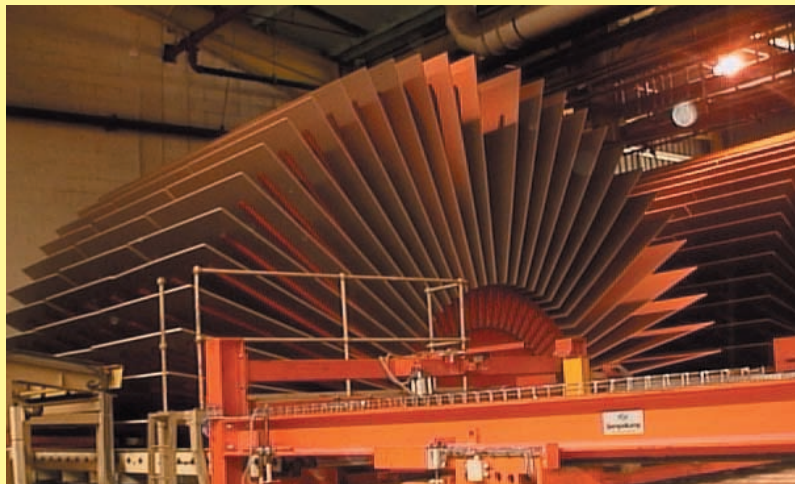
The reaction rate is maintained at the correct level by controlling three parameters: the initial temperature, the rate of adding urea, and the circulation of the cooling water.

The PLC system developed at Kronospan is programmed in 32 stages, with a target rate of addition and temperature for each stage. The targets are stored as a look-up table in the ROM of the controller. At each stage the kettle is weighed using load cells and the weight of its contents compared with the weight specified in the lookup table. The rate of feed of urea is then adjusted proportionately.

At the same time the temperature is measured and compared with its lookup table, and appropriate adjustments made to the flow rate of the cooling water. If the temperature is more than 2°C above the prescribed level, the feed of urea is cut off completely.



Chipboard production "kettle" under PLC control.



No, it's not a giant finned heatsink, it's chipboard being dried!

other early systems in which any changes made at this stage may be prohibitively expensive.

- At the operational stage PLC systems are easy to check and maintain. Later changes to the system are simple to effect.

ACKNOWLEDGEMENTS

The author thanks the following for their help in providing the information upon which this article is based: Glanbia Foods Ltd, Oswestry; Rhone-Poulenc Ltd, Norwich; Kronospan Ltd, Chirk. □

SHOP TALK

with David Barrington

MSF Signal Repeater and Indicator

The main items of concern when ordering components for the *MSF Signal Repeater and Indicator* will be the AD8532 rail-to-rail, high speed op.amp and the prealigned 60kHz ferrite, LC tuned, antenna assembly.

Unfortunately, the Analog Devices AD8532 op.amp has been dropped by the original supplier and readers may have difficulty finding a local source. However, it is listed by **Farnell** (☎ 0113 263 6311 or www.farnell.com), code 314-5888, and we understand they currently carry stocks.

We found the pre-aligned 60kHz ferrite antenna assembly under Maplin's "Modules" (sub-section "Clocks") and "Projects" sections. It can be ordered from them (☎ 0870 264 6000 or www.maplin.co.uk) and is listed as code MK72P. The latest news we have is that it is currently out of stock, Maplin are expecting new deliveries but could not give a delivery date at the time of going to press.

The BC184L transistor has a different pinout arrangement to most BC184s, so it would be wise to emphasise the suffix **L** when purchasing this part. The choice of 100μA f.s.d. meter is left to the individual constructor, but most of our component advertisers should be able to offer one at a reasonable price.

The two printed circuit boards are available from the *EPE PCB Service*, codes 306 (Repeater) and 307 (Meter), see page 529.

Perpetual Projects – Solar Powered Power Supply and Voltage Regulator

First appearances would suggest that parts for the *Perpetual Projects* series should be readily available and not cause any buying problems. But some of the components called up for the *Solar-Powered Power Supply and Voltage Regulator*, which is the "driving force" behind all projects in this series, need to be chosen carefully and may not be available from your local supplier.

Working to the prototype unit, the solar cell "load voltage" rating is quoted as 7.5V 45mA and is an RS component which was purchased through **Electromail** (☎ 01536 204555 or <http://rswww.com>), their mail order outlet, code 194-098. They also supplied the following items: 100k resistance/temperature matched n.t.c. thermistor, code 151-243; 1F 5.5V d.c. "GoldCap" memory backup electrolytic (code 107-690) and the 470μF 6.3V resin dipped aluminium electrolytic (code 221-8433) capacitor; single-turn cermet trimmer preset potentiometer, code 187-595. Note that the preset and the aluminium electrolytic are only sold on a minimum order quantity of 5 off.

Once again Maplin have discontinued stocking the required transistor – this time the TIPP31C – and cannot offer an alternative device. We have found that **Cricklewood** (☎ 020 8452 0161) currently have stocks and enquiries should be made to them. They carry a large range of semiconductor devices and can usually find those "rare" devices. The TIPP31C is also listed by **Electromail** (see above), code 638-532.

The small "Uniboard" printed circuit board (the basis for all the *Perpetual Projects*) is obtainable from the *EPE PCB Service*, code 305 (see page 529).

Stereo/Surround Sound Amplifier

Picking out the most likely components to cause concern when putting together the items needed to build the *Stereo/Surround Sound Amplifier* highlighted the stereo amplifier i.e., the stereo potentiometer and the sloping front case.

Taking the TDA2822M 1W stereo amp., again **Maplin** (☎ 0870 264 6000) are currently "out of stock" but expecting delivery very soon. In the meantime, try **Rapid Electronics** (☎ 01206 751166) code 82-0672, who do have some in stock.

The sloping front case is not critical and most of our component advertisers should be able to come up with a suitable alternative, even if the dimensions do not exactly match the prototype (Maplin code LH63T), provided they are greater than specified. The neat, chassis mounting, d.c. power socket came from **Rapid** (see above), code 20-0985.

If you wish to use and mount the 16mm dual-gauged stereo potentiometer directly on the p.c.b., as shown in the article, this came from Maplin, code VQ35Q. The printed circuit board is available from the *EPE PCB Service*, code 304.

PIC To Printer Interface

Nearly all the components used in the *PIC To Printer Interface* prototype are RS parts and any *bona fide* stockist, including some of our advertisers, will be able to obtain them for readers. If difficulties are experienced in obtaining the MAX492 dual rail-to-rail op.amp, it can be ordered through **Electromail** (☎ 01536 204555 or <http://rswww.com>), code 182-2738.

A ready-programmed PIC16F877 microcontroller can be purchased from **Magenta Electronics** (☎ 01283 565435 or www.magenta2000.co.uk) for the inclusive price of £10 (overseas add £1 p&p). They also supplied the alphanumeric display module and you should specify that you want one with a pin connector attached.

The printed circuit board (code 308) and the software is available from the *EPE PCB Service*, see page 529. The software is available on a 3.5in. PC-compatible disk (*EPE Disk 4*) for the sum of £3 (UK), to cover admin costs (for overseas, see page 529). It is also available *Free* from the EPE web site at:

[ftp://ftp.epemag.wimborne.co.uk/pubs/PICS/PICprinter](http://ftp.epemag.wimborne.co.uk/pubs/PICS/PICprinter).



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The whole of the 12-part *Teach-In 2000* series by John Becker (published in EPE Nov '99 to Oct 2000) is now available on CD-ROM. Plus the *Teach-In 2000* software covering all aspects of the series and Alan Winstanley's *Basic Soldering Guide* (including illustrations and *Desoldering*).

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ELECTRONICS CD-ROMS

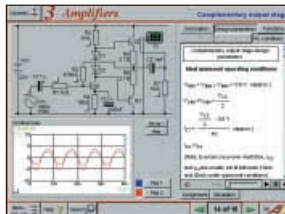
ELECTRONICS PROJECTS



Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture, circuit simulation and p.c.b. design** software is included. The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

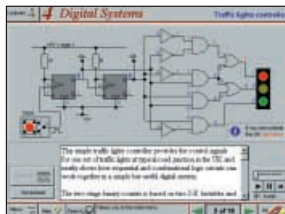
ANALOGUE ELECTRONICS



Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits. Sections on the CD-ROM include: **Fundamentals** – Analogue Signals (5 sections), Transistors (4 sections), Waveshaping Circuits (6 sections). **Op.Amps** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. **Amplifiers** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). **Filters** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). **Oscillators** – 6 sections from Positive Feedback to Crystal Oscillators. **Systems** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

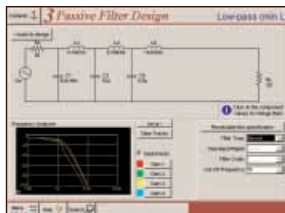
DIGITAL ELECTRONICS



Virtual laboratory – Traffic Lights

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (opposite), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen. Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units.

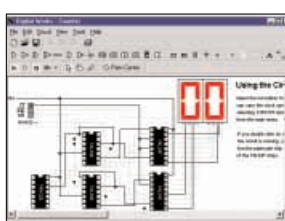
FILTERS



Filter synthesis

Filters is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to design filters. **Filter Basics** which is a course in terminology and filter characterization, important classes of filter, filter order, filter impedance and impedance matching, and effects of different filter types. **Advanced Theory** which covers the use of filter tables, mathematics behind filter design, and an explanation of the design of active filters. **Passive Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev ladder filters. **Active Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev op.amp filters.

DIGITAL WORKS 3.0

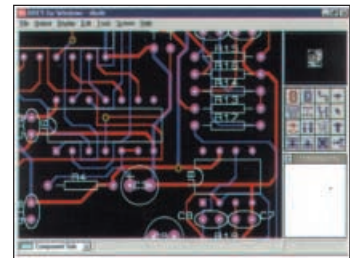


Counter project

Digital Works Version 3.0 is a graphical design tool that enables you to construct digital logic circuits and analyze their behaviour. It is so simple to use that it will take you less than 10 minutes to make your first digital design. It is so powerful that you will never outgrow its capability.

- Software for simulating digital logic circuits
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- Easy-to-use digital interface
- Animation brings circuits to life
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ELECTRONICS CAD PACK



PCB Layout

Electronics CADPACK allows users to design complex circuit schematics, to view circuit animations using a unique SPICE-based simulation tool, and to design printed circuit boards. CADPACK is made up of three separate software modules: **ISIS Lite** which provides full schematic drawing features including full control of drawing appearance, automatic wire routing, and over 6,000 parts. **PROSPICE Lite** (integrated into ISIS Lite) which uses unique animation to show the operation of any circuit with mouse-operated switches, pots, etc. The animation is compiled using a full mixed mode SPICE simulator. **ARES Lite** PCB layout software allows professional quality PCBs to be designed and includes advanced features such as 16-layer boards, SMT components, and even a **fully functional autorouter**.

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C for PICmicro Microcontrollers is designed for students and professionals who need to learn how to use C to program embedded microcontrollers. This product contains a complete course in C that makes use of a virtual C PICmicro which allows students to see code execution step-by-step. Tutorials, exercises and practical projects are included to allow students to test their C programming capabilities. Also includes a complete Integrated Development Environment, a full C compiler, Arizona Microchip's MPLAB assembler, and software that will program a PIC16F84 via the parallel printer port on your PC. (Can be used with the *PICtutor* hardware – see opposite.)

Although the course focuses on the use of the PICmicro series of microcontrollers, this product will provide a relevant background in C programming for any microcontroller.

PRICES

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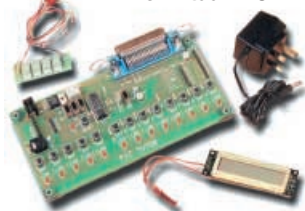
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The Virtual PIC



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Whilst the CD-ROM can be used on its own, the physical demonstration provided by the **PICtutor Development Kit**, plus the ability to program and test your own PIC16x84s, really reinforces the lessons learned. The hardware will also be an invaluable development and programming tool for future work. Two levels of PICtutor hardware are available – Standard and Deluxe. The **Standard** unit comes with a battery holder, a reduced number of switches and no displays. This version will allow users to complete 25 of the 39 Tutorials. The **Deluxe** Development Kit is supplied with a plug-top power supply (the **Export** Version has a battery holder), all switches for both PIC ports plus I.C.D. and 4-digit 7-segment I.E.D. displays. It allows users to program and control all functions and both ports of the PIC. All hardware is supplied **fully built and tested** and includes a PIC16F84.

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The **Parts Gallery** will help students to recognise common electronic components and their corresponding symbols in circuit diagrams. Selections include: **Components, Components Quiz, Symbols, Symbols Quiz, Circuit Technology**

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Essential information for anyone undertaking GCSE or "A" level electronics or technology and for hobbyists who want to get to grips with project design. Over seventy different Input, Processor and Output modules are illustrated and fully described, together with detailed information on construction, fault finding and components, including circuit symbols, pinouts, power supplies, decoupling etc.

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Minimum system requirements for these CD-ROMs: PC with 486/166MHz, VGA+256 colours, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 95/98, mouse, sound card, web browser.

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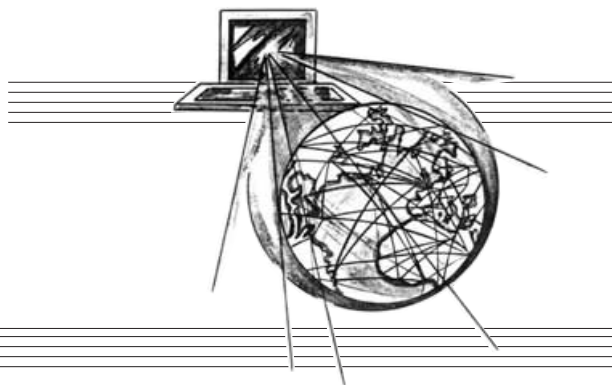
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Google Rocks!

IN LAST month's *Net Work* we discussed the Open Directory Project (ODP) available at www.dmoz.org which is claimed to be the largest human-edited web search resource on the Internet. It has a clean front end with none of the usual portal-type distractions.

Today, the other best-known search engine has to be Google (www.google.com). The author considers this resource to be so significant that this month we return to the Google web site once again – this time to look at Usenet and the advanced features Google's downloadable toolbar offers to make life easier.

The author strongly recommends installing the Google toolbar into Internet Explorer 5 or higher, so that a search box and other options are always to hand. Google's Internet Explorer toolbar has many useful benefits which soon become apparent in use: for example you can Highlight any search phrase "hits" (useful on long or complex pages – multiple terms are highlighted in different colours), and using Word Find you can scroll from one search hit on a page to the next one.

Deja View

There are more handy options in the Google toolbar which regular web users will soon appreciate. One of the most significant is the direct link to Usenet (newsgroups). Many old hands on the Internet mourned the loss of *Deja News*, the best-known archive of newsgroup postings established in 1995. It's all very well searching the world-wide web for answers, but if you wanted to know what your peers think – perhaps you had a particular software or hardware problem and wondered if anyone else had overcome that same problem – then the savvy net user would head over to *Deja News* to trawl through the Usenet archives.

These archives contain some 500 million messages and are considered by many to be public property, which is why there was an outcry when *Deja* folded and the archives, trademarks and *Deja's* domain names landed in Google's lap. In fact it could be a marriage made in Heaven, because there is nothing Google likes better than the challenge of searching through a terabyte of data – fast. Even on a 56K dialup connection, results are returned virtually instantaneously.

Usenet Googified

During the first half of 2001 Google has therefore busied itself with Usenet, and the result is that a powerful beta version of *Google News* is online at <http://groups.google.com>. Happily, Google Groups is easily accessible via the Explorer toolbar where installed, and the archive did an eerily efficient job of pulling up many of my own posts dating back to the mid 1990s! A Search Usenet button is also available in the Google Toolbar – excellent!

If you don't have the toolbar, you should still bookmark Google Groups and become familiar with its features; more than once I have resolved some thorny problems by searching Usenet archives; in fact I have just received an E-mail from someone who searched Google and found one of my posts dated 1997 which he wanted to discuss with me! Now you have half a decade of human conversation at your fingertips.

You can now also post onto Usenet using Google, and the way to ensure that your post is **not** archived, if required, is to add the line *X-No-Archive: yes* into the header of your message. Furthermore, as many old hands will know, posting into Usenet means that your E-mail address will quickly be scooped up by spammers (junk E-mailers) so you should *never* use your regular daytime E-mail address anywhere in your Usenet message.

For those using other operating systems or browsers, Google does offer a search function restricted to Linux or BSD users. Macintosh users can see the Options page ("Googlify your browser") for details of the Sherlock plug-in for Apple Macs.

There's yet more! The Google toolbar has an optional "Search Directory" button which combines the Open Directory Project (see last month) together with Google's own PageRank feature. This indicates how importantly Google's highly complex algorithms have rated a web page hit for relevance. Last of all, the toolbar's drag and drop feature allows you to drop any text or URL from the main browser into the toolbar to start a search.

All in all, Google could be your first port of call when hunting for answers on the Internet. Even so, it is still possible that Google may not always return very many suitable hits, especially if you are looking for obscure information (remember to trawl through newsgroups too). It is worth having a second search engine up your sleeve.

Alta Vista (www.altavista.com) is another search engine which appears to be re-inventing itself as . . . a search engine. Its portal content has been stripped away leaving a leaner page that harks back to the mid 90's, and it incorporates Babel Fish, which enables both text and web sites to be translated between a number of languages.

Alta Vista was originally created by the computer manufacturer Digital Equipment as a living testimony to the power of its own systems (see *Net Work*, March 2000) before the engine was catapulted into commercialisation when DEC sold out. Many others use Yahoo or Ask Jeeves instead.

A Word from Our Sponsors

Many portal sites rely on good old advertising for their revenue, in spite of the mounting evidence of the decreasing effectiveness of on-line advertising, specifically banner adverts. Predictably, users have acquired the ability to focus on the content and block out banner adverts altogether, so the click-through ratios of typical banners are very low indeed.

Banner adverts are a standard size, usually 468 × 60 pixels. Most users will not wait for a banner to download and instead they will start to read the page as soon as it starts to download. Hence we recognise the "start" of a banner ad and we block it out. Indeed software is available which will block out adverts or will prevent time-consuming animated gifs from downloading at all.

One of the latest trends in on-screen advertising is the use of *superstitial*, *interstitial* and *transitional* adverts. Superstitials load in the background at "quiet" times and only start to play when fully loaded. Interstitials are more irritating – they are often in the form of pop-up windows that open immediately, followed by a delay while the advert loads. Unlike banner adverts, you cannot help but notice – because you usually have to close the window to dismiss it. Last of all, the *transitional* advert runs when fully downloaded, and will play in the main browser window for a few seconds when the next page is being loaded.

Payback Time

As the revenue from traditional banner advertising falls, and businesses have to start to pay several hundred dollars to be registered on major search engines, it seems that payback time is dawning on the Internet. Users have always enjoyed a vast amount of free content paid for by advertising, but now there are signs that online advertising will become a lot less subtle and a lot more "in your face".

That's it for this month, so as Babel Fish would say in Spanish, *las gracias por leer esto, le consideran próximo el mes!* My E-mail address is alan@epemag.co.uk.

We can supply back issues of *EPE* by post, most issues from the past three years are available. An *EPE* index for the last five years is also available – see order form. Alternatively, indexes are published in the December issue for that year. Where we are unable to provide a back issue a photostat of any *one article* (or *one part* of a series) can be purchased for the same price. Issues from Dec. 2000 onwards are also available to download from www.epemag.com.

DID YOU MISS THESE?

MAR '00

PROJECTS • EPE ICEbreaker • High Performance Regenerative Receiver-1 • Parking Warning System • Automatic Train Signal.
FEATURES • Teach-In 2000 – Part 5 • Practically Speaking • Technology Timelines-2 • Ingenuity Unlimited • Circuit Surgery • New Technology Update • Net Work – The Internet.

APRIL '00

PROJECTS • Flash Slave • Garage Link • Micro-PICscope • High Performance Regenerative Receiver-2.
FEATURES • Teach-In 2000-Part 6 • Ingenuity Unlimited • Technology Timelines-3 • Circuit Surgery • Interface • Telcan Home Video • Net Work – The Internet.

MAY '00

PROJECTS • Versatile Mic/Audio Preamplifier • PIR Light Checker • Low-Cost Capacitance Meter • Multi-Channel Transmission System-1.
FEATURES • Teach-In 2000-Part 7 • Technology Timelines-4 • Circuit Surgery • Practically Speaking • Ingenuity Unlimited • Net Work – The Internet • *FREE* Giant Technology Timelines Chart.

JUNE '00

PROJECTS • Atmospheric Electricity Detector-1 • Canute Tide Predictor • Multi-Channel Transmission System-2 • Automatic Nightlight.
FEATURES • Teach-In 2000 – Part 8 • Technology Timelines-5 • Circuit Surgery • Interface • New Technology Update • Ingenuity Unlimited • Net Work – The Internet.



JULY '00

PROJECTS • G-Meter • Camera Shutter Timer PIC-Gen Frequency Generator/Counter • Atmospheric Electricity Detector-2.
FEATURES • Teach-In 2000-Part 9 • Practically Speaking • Ingenuity Unlimited • Circuit Surgery • PICO DrDAQ Reviewed • Net Work – The Internet.

AUG '00

PROJECTS • Handy-Amp • EPE Moodloop • Quiz Game Indicator • Door Protector
FEATURES • Teach-In 2000-Part 10 • Cave Electronics • Ingenuity Unlimited • Circuit Surgery • Interface • New Technology Update • Net Work – The Internet.

SEPT '00

PROJECTS • Active Ferrite Loop Aerial • Steeplechase Game • Remote Control IR Decoder • EPE Moodloop Power Supply.
FEATURES • Teach-In 2000-Part 11 • New Technology Update • Circuit Surgery • Ingenuity Unlimited • Practically Speaking • Net Work – The Internet Page.

OCT '00

PROJECTS • Wind-Up Torch • PIC Dual-Chan Virtual Scope • Fridge/Freezer Alarm • EPE Moodloop Field Strength Indicator.
FEATURES • Teach-In 2000-Part 12 • Interface • Ingenuity Unlimited • New Technology Update • Circuit Surgery • Peak Atlas Component Analyser Review • Net Work – The Internet Page.

NOV '00

PROJECTS • PIC Pulsometer • Opto-Alarm System • Sample-and-Hold • Handclap Switch.
FEATURES • The Schmitt Trigger-Part 1 • Ingenuity Unlimited • PIC Toolkit Mk2 Update V2.4 • Circuit Surgery • New Technology Update • Net Work – The Internet • *FREE* Transistor Data Chart.



DEC '00

PROJECTS • PIC-Monitored Dual PSU-Part1 • Static Field Detector • Motorists' Buzz-Box • Twinkling Star • Christmas Bubble • Festive Fader • PICtogram.
FEATURES • The Schmitt Trigger-Part 2 • Ingenuity Unlimited • Interface • Circuit Surgery • New Technology Update • Quasar Kits Review • Net Work – The Internet • 2000 Annual Index.

JAN '01

PROJECTS • Versatile Optical Trigger • UFO Detector and Event Recorder • Two-Way Intercom • PIC-Monitored Dual PSU-Part 2.
FEATURES • Using PICs and Keypads • The Schmitt Trigger-Part 3 • New Technology Update • Circuit Surgery • Practically Speaking • Ingenuity Unlimited • CIRSIM Shareware Review • Net Work – The Internet.

FEB '01

PROJECTS • Ice Alert • Using LM3914-6 Bargraph Drivers • Simple Metronome • PC Audio Power Meter.
FEATURES • The Schmitt Trigger-Part 4 • Ingenuity Unlimited • Circuit Surgery • New Technology Update • Net Work – The Internet • *Free* 16-page supplement – How To Use Graphics L.C.D.s With PICs.

MAR '01

PROJECTS • Doorbell Extender • Body Detector • DIY Tesla Lightning • Circuit Tester
FEATURES • Understanding Inductors • The Schmitt Trigger-Part 5 • Circuit Surgery • Interface • New Technology Update • Net Work – The Internet Page.

APRIL '01

PROJECTS • Wave Sound Effect • Intruder Alarm Control Panel-Part 1 • Sound Trigger • EPE Snug-Bug Pet Heating Control Centre.
FEATURES • The Schmitt Trigger-Part 6 • Practically Speaking • Ingenuity Unlimited • Circuit Surgery • Net Work – The Internet Page • *FREE* supplement – An End To All Disease.

MAY '01

PROJECTS • Camcorder Mixer • PIC Graphics L.C.D. Scope • D.C. Motor Controller • Intruder Alarm Control Panel-Part 2.
FEATURES • The Schmitt Trigger-Part 7 • Interface • Circuit Surgery • Ingenuity Unlimited • New Technology Update • Net Work – The Internet Page.



JUNE '01

PROJECTS • Hosepipe Controller • In-Circuit Ohmmeter • Dummy PIR Detector • Magfield Monitor.
FEATURES • Controlling Jodrell Bank • PIC1687x Extended Memory Use • Practically Speaking • Ingenuity Unlimited • New Technology Update • Circuit Surgery • Net Work – The Internet Page.

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MSF SIGNAL REPEATER AND INDICATOR



ANDY FLIND

How to receive MSF radio clock signals in a "shielded" building.

IN common with the author's *Multi-channel Transmission System* featured in the May and June 2000 issues, this project began with a request from the local Hospital Radio group.

The group use radio-controlled clocks working from the 60kHz MSF signals transmitted from Rugby to assist with the synchronisation of some of their broadcast items. They soon discovered that these clocks were unable to receive the signal in their new studio, which is located in the interior of a large steel-framed building.

TO THE RESCUE!

A way of overcoming this problem was required so once again the author's services were called upon. Clearly the simplest approach would be to place a receiving antenna somewhere close to the edge of the building or even outside it, conduct the signal to the studio through a screened cable and then re-radiate it close to the clocks.

Small ferrite antenna assemblies are readily available complete with capacitors tuned to the Rugby MSF signal so they'd tried simply attaching one to each end of a length of 75 ohm UHF TV co-axial cable, but it didn't work! "The signal seemed to get lost in the cable", was their comment.

In retrospect, the probable cause of the failure was the cable's capacitance which would have shifted both antenna centre

frequencies a long way from the required 60kHz. A circuit to buffer and amplify the signal at the receiving end seemed the most promising solution and ultimately led to the development of this project. It seems likely that the problem of MSF clocks failing to work in steel-framed buildings may be quite common since many office and factory premises use this form of construction, so this circuit may find plenty of applications.

There may also be electronics enthusiasts who would like to work with the signal and would appreciate its availability at an easily usable level and source impedance on the workbench, although where only the demodulated data signal is required a complete receiver module is available at low cost. More details of this can be found in the November '97 issue where it was used in John Becker's excellent *EPE Time Machine*. However, for more basic experiments this design may be useful, especially as it features a simple add-on circuit to indicate the relative incoming signal strength.

REPEATER CIRCUIT

The circuit of the repeater part of the project is shown in Fig.1. The antenna is a small ferrite rod supplied pre-wound with an enamelled copper wire coil and fitted

with a parallel tuning capacitor, with a rubber sleeve to hold it in place.

Like all parallel-tuned resonant circuits it should only be connected to a high impedance since resistive or capacitive loading will tend to de-tune it and adversely affect performance. For this reason it is first buffered by the field effect transistor (f.e.t.) TR1, which does not amplify the signal voltage but greatly reduces its impedance. The output from TR1 is taken from the source (s) connection.

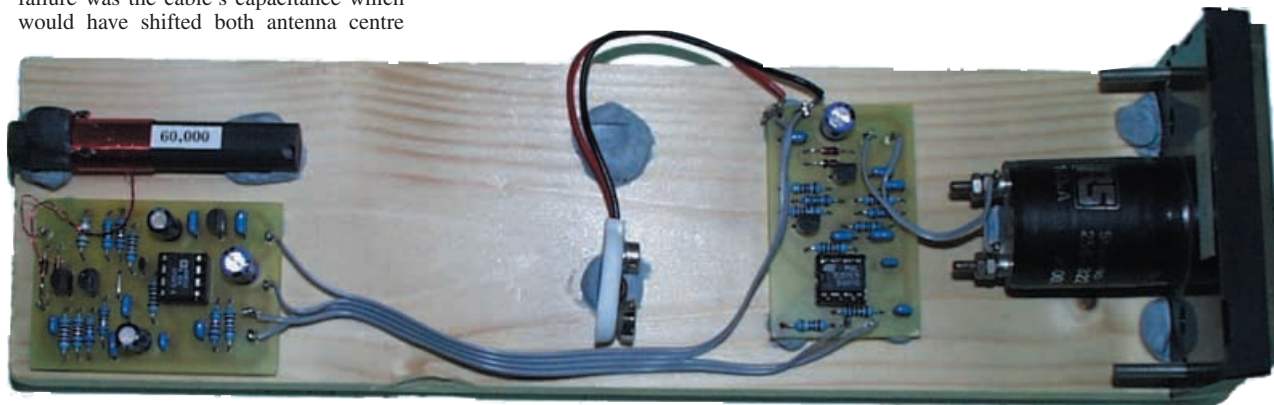
Diodes D1 and D2 protect TR1 from excessively high signal levels should these be encountered. Transistor TR2 provides a voltage gain of about 20, set by the values of resistors R4 and R5.

An AD8532 dual op.amp, IC1, was selected for its features of high speed, rail-to-rail outputs, good output current capability and ability to operate from a 5V supply. The first amplifier IC1a provides further voltage gain of about 10 and incorporates some upper and lower frequency response tailoring with capacitors C6 and C7.

Finally, the signal passes through a passive low-pass filter comprised of resistor R10 and capacitor C8 to the second amplifier, IC1b, which is used as a unity-gain buffer. Resistor R11 protects the output from accidental short circuits.

BE POSITIVE

A problem with high-gain circuits is unwanted positive feedback which can cause instability. Often the path taken by such feedback is through the power supply



rails. Two measures have been taken in this circuit to prevent this occurring.

The first is the use of the local supply voltage regulator IC2 to provide a constant 5V supply. Together with decoupling capacitors C9 and C10, this virtually eliminates signal frequency fluctuations in the supply and also allows the circuit to operate from a wide supply voltage range, including 12V, which is readily available from the Hospital Radio group's equipment.

from Rugby using a 100 per cent modulation system, meaning that the signal is either on or off.

A concern during the design of this project was that the high Q of the tuned ferrite aerials would cause long rise and fall times in the re-transmitted signal which might in turn render it unrecognisable by the clocks. However, in practice this has not proved to be a problem. Two clocks of very different types were placed next to the

output antenna and both synchronised correctly to its signal with no difficulty whatsoever.

REPEATER CONSTRUCTION

The components for the repeater part of the project are all mounted on a small printed circuit board as shown in Fig.2. This board is available from the *EPE PCB Service*, code 306.

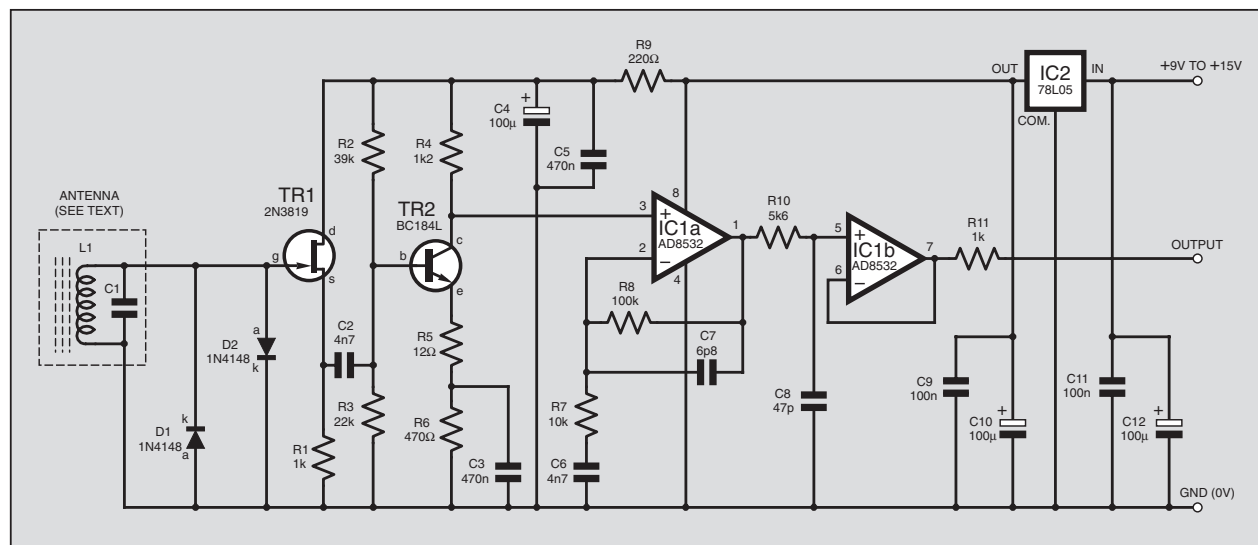


Fig.1. Circuit diagram for the MSF Signal Amplifier and Repeater.

The second measure is the use of some additional supply decoupling for the two transistors, applied with resistor R9 and capacitors C4 and C5.

BANDWIDTH

The complete circuit has an overall bandwidth extending from 20kHz to 200kHz with the maximum voltage gain of about 200 centred around 60kHz, which covers the required frequency and helps to reject noise at higher and lower frequencies. At the author's location, about 130 miles from the Rugby transmitter, the output level is about 45mV peak-to-peak, which is easily displayed on an oscilloscope. The signal is not constant of course; it pulses slowly with a format corresponding to the data being transmitted, which in itself is quite interesting to watch.

The output from the circuit is transferred to the required location by ordinary 75 ohm UHF TV co-axial cable, with the screen connected to ground (0V) to minimise problems of signal leakage. Close to the clock, another resonant ferrite antenna assembly is connected to it in series with a 10nF ceramic capacitor and a 10kΩ resistor (see Fig.3). The resistor provides adequate drive whilst minimising capacitive and resistive loading of the tuned circuit.

LOCAL TIME

In practice this was found to produce a strong but localised signal field which is exactly what is required. If more than one clock has to operate from this arrangement it should be possible to connect several extra tuned circuits to the cable, each with a 10nF capacitor and a 10kΩ resistor in series as with the first. Data is transmitted

COMPONENTS

Approx. Cost
Guidance Only
excluding case and meter.

£26

Main Repeater Unit

Resistors

R1, R11	1k (2 off)
R2	39k
R3	22k
R4	1k2
R5	12Ω
R6	470Ω
R7	10k
R8	100k
R9	220Ω
R10	5k6

All 1% 0.6W metal film.

Capacitors

C1	part of antenna assembly (see text)
C2, C6	4n7 resin-dipped ceramic (2 off)
C3, C5	470n resin-dipped ceramic (2 off)
C4, C10	100μ radial elect. 10V (2 off)
C7	6p8 ceramic plate
C8	47p resin-dipped ceramic
C9, C11	100n resin-dipped ceramic (2 off)
C12	100μ radial elect. 25V

Semiconductors

D1, D2	1N4148 signal diode (2 off)
TR1	2N3819 <i>n</i> -channel f.e.t.
TR2	BC184L <i>n</i> p <i>n</i> transistor (2 off)
IC1	AD8532 dual op.amp
IC2	78L05 +5V 100mA voltage regulator

Miscellaneous

L1/C1	60kHz ferrite antenna assembly
-------	--------------------------------

TB1 4-way screw terminal block, p.c.b. mounting
Printed circuit board, available from the *EPE PCB Service*, code 306; 8-pin d.i.l. socket; solder pins; solder, etc.

Signal Strength Meter

Resistors

R1	10k
R2	39k
R3	1k
R4	22k
R5	1k5
R6	1k8
R7	120k
R8	4k7
R9	2k2

All 1% 0.6W metal film.

Capacitors

C1, C3	10n resin-dipped ceramic (2 off)
C2, C5	100n resin-dipped ceramic (4 off)
C4	470n resin-dipped ceramic
C8	100μ radial elect. 25V

Semiconductors

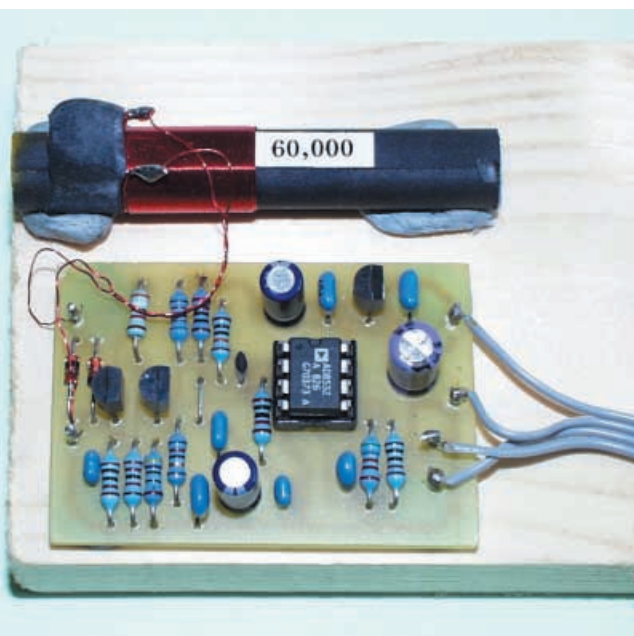
D1, D2	1N4148 signal diode (2 off)
TR1, TR2	BC184L <i>n</i> p <i>n</i> transistor (2 off)
IC1	TL071 f.e.t. op.amp

Miscellaneous

ME1	100μA f.s.d. moving-coil meter
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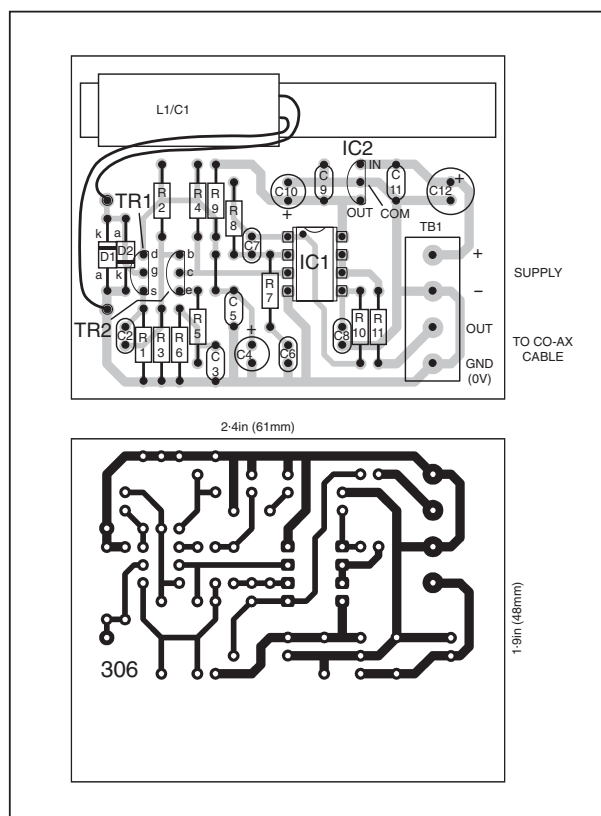
Printed circuit board, available from the *EPE PCB Service*, code 307; 8-pin d.i.l. socket; solder pins; solder, etc.





Completed prototype repeater circuit board.

Fig.2 (right). Printed circuit board topside component layout and full-size copper foil master for the Repeater circuit.



Construction should begin with the fitting of all resistors, the two diodes, the small ceramic capacitors, a d.i.l. (dual-in-line) socket for IC1, the three electrolytic capacitors and the regulator IC2. The terminal block TB1 may also be fitted at this point and a pair of solder pins can be provided for connections to the antenna coil.

A supply of between 9V and 15V should be applied, and the regulated 5V supply should be checked as present and correct.

The two transistors may be fitted next. A temporary short circuit link wire should be connected between the input and the 0V line, and power re-applied. If all is well, the collector (c) of TR2 should have a d.c. voltage of about 2.2V and the supply voltage to the transistors, measured at the top of R2 (as seen in Fig.2), should be about 4.4V. If this appears correct, IC1 can be inserted and the circuit powered again.

The two outputs of IC1, pin 1 and pin 7, should both show d.c. voltages of about 2.2V and the total supply current should be about 6.3mA. If so, the board is probably OK so it can be completed by fitting and connecting the ferrite antenna, L1.

TRANSMISSION TESTS

The antenna may be attached to the board with a couple of blobs of Blu-Tack, which seems to increase in strength over time and has proved more than adequate in the prototype. Further testing will require test equipment (or a steel-framed building and a clock!) or the signal strength indicator unit which will be described next.

If an oscilloscope is available it may be used to display the output of the board, which will vary according to the range from the transmitter, but will probably be a few tens of millivolts. It should appear as a 60kHz sinewave, pulsing on and off at around 1Hz or slightly faster.

This part of the project can be fitted into a case if necessary, but any housing used should be made of plastic with no large metal components close to the antenna. In areas of poor signal strength it may be best to use a weatherproof housing and site the unit outside to obtain a better signal. The method of connecting the re-radiating antenna to the unit is shown in Fig.3.

This may also be housed in a small plastic case for a neat appearance, though in some cases it may be possible to simply hide it behind the clock. The negative supply should be earthed at some point to keep signal radiation from the screened output cable to a minimum.

SIGNAL METER

During the design of the repeater amplifier it was decided that a portable signal strength indicator would be useful as it might assist in finding the best spot to

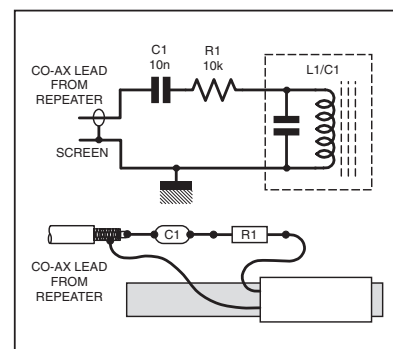


Fig.3. Re-radiating antenna circuit and connection.

place the receiving antenna, in orientating it for the strongest signal, and in checking the output field strength at the point where it was re-radiated.

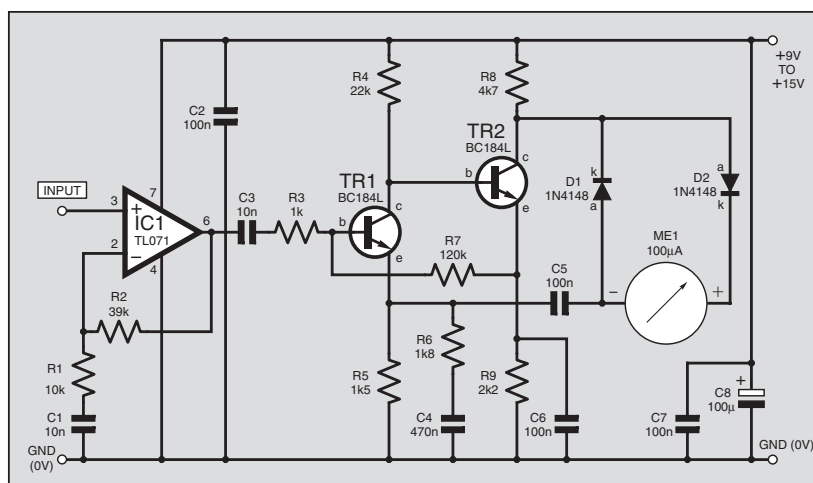
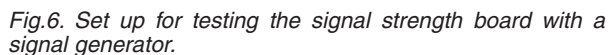
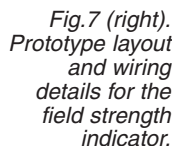
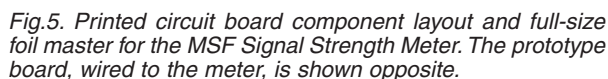


Fig.4. Complete circuit diagram for the MSF Signal Strength meter.



The meter is a 100 μ A moving coil type. Capacitors C2, C7 and C8 are local supply decouplers to help maintain stability. The supply voltage for this circuit may be anywhere between about 7V and 15V, so a 9V PP3 battery may be used for portability. Construction of this part of the circuit consists of assembling the components on the p.c.b. as shown in Fig.5. This board is available from the *EPE PCB Service*, code 307.

If it is desired to test the circuit on its own using a signal generator, it will be necessary to provide input biasing. This can be done with a couple of 100k Ω resistors and a 100nF coupling capacitor as shown in Fig.6. The complete circuit should draw a supply current of about 2.5mA.

Connecting the unit to the first board requires some care. If the two boards are too close to each other, feedback will take place between them and cause false high meter readings, so they should be kept a reasonable distance apart and the wiring between them and the meter should be kept short and tidy.



The layout shown in Fig.7 works well and, as can be seen from the photograph, the prototype was assembled on a piece of wood with some Blu-Tack! Well, it was never intended to be more than a lash-up for spot checks on location and it performed that function very well indeed.

ENCLOSURES

If a more professional job is required, a plastic case can be used instead with a similar layout, but it is suggested that the layout is tested before cutting any holes in the case. It was also found that providing a Ground connection by touching the circuit's negative supply rail approximately doubled the meter reading, and that simply resting a finger on the metal case of the battery achieves a similar effect.

If a plastic case is used a small metal touch-plate connected to the negative supply could be provided for this contact. A metal case **must not** be used, of course, as this would prevent the signal from reaching the antenna.

INSTALLATION

In use, it has been found that strong signal sources such as computers can "block" the repeater unit, but apart from this limitation it works well. It certainly proved possible to demonstrate a complete lack of signal within the metal-framed hospital building and to locate a spot above a false ceiling adjacent to an outside wall where an adequate signal was available.

It also showed the strong but short-ranged nature of the output signal close to the clock, and allowed the selection of a suitable value for the series resistor used

to drive the output antenna, which in some cases may be higher or lower than the 10kΩ value suggested.

It assisted with correct orientation for the antenna above the ceiling although this may also be carried out with a compass. As many readers will know, ferrite aerials give greatest output when placed at right angles to the direction in which the transmitter lies.

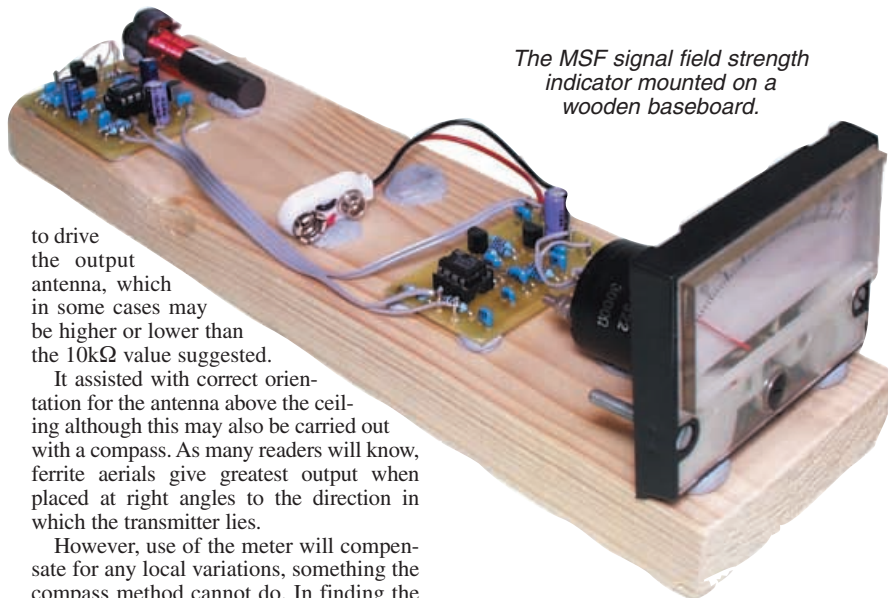
However, use of the meter will compensate for any local variations, something the compass method cannot do. In finding the direction of the transmitter it may prove easier to find the "null" or smallest signal orientation due to the pulsed nature of the transmission and then place the receiving antenna at right angles to this.

TRANSMITTER MAINTENANCE

Finally, it should be noted that the Rugby transmitter is occasionally switched off for maintenance, so if no signals are visible, it is worth checking this out first before assuming there may be a fault in the project.

There is a quarterly maintenance period which normally takes place on the first Tuesday of each January, April, July and

The MSF signal field strength indicator mounted on a wooden baseboard.



October from 1000 to 1400 hours GMT (1100 to 1500 BST in summer time).

An annual maintenance period takes place over a two week period in the summer, with the signal being absent during the daytime but restored overnight (although this is not guaranteed). The period for 2001 is from 1300 BST Monday 16 July to 1300 BST Monday 30 July.

More details about the MSF transmissions can be obtained from the National Physical Laboratory (NPL), Teddington, Middx TW11 0LW. Tel: 0208 977 3222.

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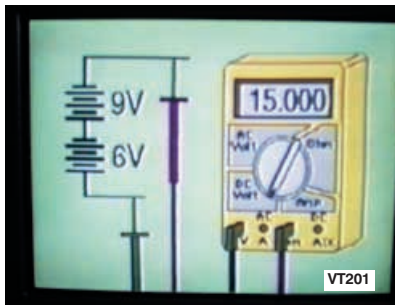
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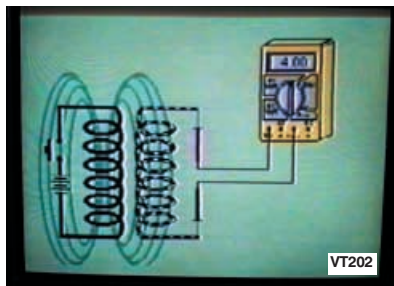
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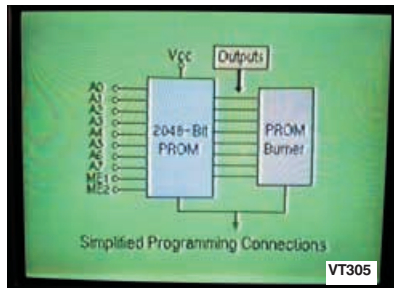
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The topics covered in this book include: The broadcast bands and their characteristics; The amateur bands and their characteristics; The propagation of radio signals; Simple aerials; Making an earth connection; Short wave crystal set; Simple t.r.f. receivers; Single sideband reception; Direct conversion receiver. Contains everything you need to know in order to get started in this absorbing hobby.

88 pages

Order code BP275

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Computers and Computing

MULTIMEDIA ON THE PC

Ian R. Sinclair

In this book, you'll find out what a CD ROM is, how it works, and why it is such a perfect add-on for a PC, allowing you to buy programmes, text, graphics and sound on a CD. It also describes the installation of a CD ROM drive and a sound card, pointing out the common problems that arise, and then shows how to use them to create a complete multimedia presentation that contains text, photos, a soundtrack with your own voice recorded as a commentary, even animation and edited video footage.

184 pages

Order code PC112

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HOW TO BUILD YOUR OWN PC

Morris Rosenthal

More and more people are building the own PCs. They get more value for their money, they create exactly the machine they want, and the work is highly satisfying and actually fun. That is, if they have a unique beginner's guide like this one, which visually demonstrates how to construct a state-of-the-art computer from start to finish.

Through 150 crisp photographs and clear but minimal text, readers will confidently absorb the concepts of computer building. The extra-big format makes it easy to see what's going on in the pictures. For non-specialists, there's even a graphical glossary that clearly illustrates technical terms. The author goes "under the hood" and shows step-by-step how to create a socket 7 (Pentium and non-intel chipsets) and a Slot 1 (Pentium II) computer, covering: What first-time builders need to know; How to select and purchase parts; How to assemble the PC; How to install Windows 98. The few existing books on this subject, although badly outdated, are in steady demand. This one delivers the expertise and new technology that fledgling computer builders are eagerly looking for.

224 pages - large format

Order code MGH2

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UNDERSTANDING PC SPECIFICATIONS

R. A. Penfold (Revised Edition)

If you require a microcomputer for business applications, or a high quality home computer, an IBM PC or compatible is often the obvious choice. They are competitively priced, and are backed up by an enormous

range of applications programs, hardware add-ons, etc. The main difficulty for the uninitiated is deciding on the specification that will best suit his or her needs. PCs range from simple systems of limited capabilities up to complex systems that can happily run applications that would have been considered beyond the abilities of a microcomputer not so long ago. It would be very easy to choose a PC system that is inadequate to run your applications efficiently, or one which goes beyond your needs and consequently represents poor value for money.

This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, etc); Maths co-processors; Input devices (keyboards, mice, and digitisers); Memory, including both expanded (EMS) and extended RAM; RAM disks and disk caches; Floppy disk drive formats and compatibility; Hard disk drives (including interleaved factors and access times); Display adaptors, including all standard PC types (CGA, Hercules, Super VGA, etc); Contains everything you need to know if you can't tell your EMS from your EGA!

128 pages

Order code BP282

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Theory and Reference

Bebop To The Boolean Boogie

By Clive (call me Max)
Maxfield
Specially imported by EPE –
Excellent value

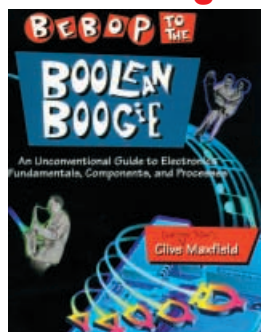
An Unconventional Guide to
Electronics Fundamentals,
Components and Processes

This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more (including a recipe for a truly great seafood gumbo!). Hundreds of carefully drawn illustrations clearly show the important points of each topic. The author's tongue-in-cheek British humor makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. A great reference for your own shelf, and also an ideal gift for a friend or family member who wants to understand what it is you do all day. . . .

470 pages – large format

Order code BEB1

£26.95



Bebop Bytes Back

By Clive "Max" Maxfield
and Alvin Brown

Specially imported by EPE –
Excellent value

An Unconventional Guide
To Computers

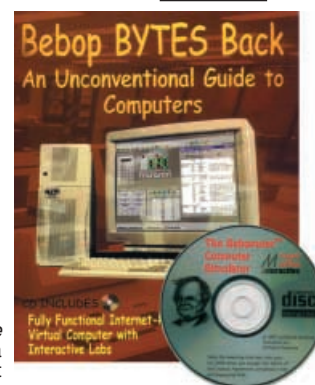
Plus **FREE CD-ROM** which includes:
Fully Functional Internet-Ready
Virtual Computer with Interactive Labs

This follow-on to *Bebop to the Boolean Boogie* is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design. . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the accompanying CD-ROM (for Windows 95 machines only) contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the book contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers.

Over 500 pages – large format

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DIGITAL ELECTRONICS – A PRACTICAL APPROACH
With **FREE Software: Number One Systems – EASY-PC**
Professional XM and Pulsar (Limited Functionality)
Richard Monk

FREE SOFTWARE

Covers binary arithmetic, Boolean algebra and logic gates, combination logic, sequential logic including the design and construction of asynchronous and synchronous circuits and register circuits. Together with a considerable practical content plus the additional attraction of its close association with computer aided design including the **FREE** software.

There is a 'blow-by-blow' guide to the use of **EASY-PC** Professional XM (a schematic drawing and printed circuit board design computer package). The guide also conducts the reader through logic circuit simulation using Pulsar software. Chapters on p.c.b. physics and p.c.b. production techniques make the book unique, and with its host of project ideas make it an ideal companion for the integrative assignment and common skills components required by BTEC and the key skills demanded by GNVQ. The principal aim of the book is to provide a straightforward approach to the understanding of digital electronics.

Those who prefer the 'Teach-In' approach or would rather experiment with some simple circuits should find the book's final chapters on printed circuit board production and project ideas especially useful.

250 pages

Order code NE28

£17.99

DIGITAL GATES AND FLIP-FLOPS
Ian R. Sinclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.

200 pages

Order code PC106

£9.95

Music, Audio and Video

**AN INTRODUCTION TO LOUDSPEAKERS
AND ENCLOSURE DESIGN**
V. Capel

This book explores the various features, good points and snags of speaker designs. It examines the whys and wherefores so that the reader can understand the principles involved and so make an informed choice of design, or even design loudspeaker enclosures for him – or herself. Crossover units are also explained, the various types, how they work, the distortions they produce and how to avoid them. Finally there is a step-by-step description of the construction of the *Kapellmeister* loudspeaker enclosure.

148 pages

Temporarily out of print

ELECTRONIC MUSIC AND MIDI PROJECTS
R. A. Penfold

Whether you wish to save money, boldly go where no musician has gone before, rekindle the pioneering spirit, or simply have fun building some electronic music gadgets, the designs featured in this book should suit your needs. The projects are all easy to build, and some are so simple that even complete beginners at electronic project construction can tackle them with ease. Stripboard layouts are provided for every project, together with a wiring diagram. The mechanical side of construction has largely been left to individual constructors to sort out, simply because the vast majority of project builders prefer to do their own thing in this respect.

None of the designs requires the use of any test equipment in order to get them set up properly. Where any setting up is required, the procedures are very straightforward, and they are described in detail.

Projects covered: Simple MIDI tester, Message grabber, Byte grabber, THRU box, MIDI auto switcher, Auto/manual switcher, Manual switcher, MIDI patchbay, MIDI controlled switcher, MIDI lead tester, Program change pedal, Improved program change pedal, Basic mixer, Stereo mixer, Electronic swell pedal, Metronome, Analogue echo unit.

138 pages

Order code PC116

£10.95

**VIDEO PROJECTS FOR THE ELECTRONICS
CONSTRUCTOR**
R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

Complete with explanations of how the circuit works, shopping lists of components, advice on construction, and guidance on setting up and using the projects, this invaluable book will save you a small fortune.

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

124 pages

Order code PC115

£10.95

COMPUTERS AND MUSIC – AN INTRODUCTION
R. A. Penfold

Computers are playing an increasingly important part in the world of music, and the days when computerised music was strictly for the fanatical few are long gone.

If you are more used to the black and white keys of a synth keyboard than the QWERTY keyboard of a computer, you may be understandably confused by the jargon and terminology bandied about by computer buffs. But fear not, setting up and using a computer-based music making system is not as difficult as you might think.

This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This

book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully.

174 pages

Temporarily out of print

**THE INVENTOR OF STEREO – THE LIFE AND WORKS
OF ALAN DOWER BLUMLEIN**
Robert Charles Alexander

This book is the definitive study of the life and works of one of Britain's most important inventors who, due to a cruel set of circumstances, has all but been overlooked by history.

Alan Dower Blumlein led an extraordinary life in which his inventive output rate easily surpassed that of Edison, but whose early death during the darkest days of World War Two led to a shroud of secrecy which has covered his life and achievements ever since.

His 1931 Patent for a Binaural Recording System was so revolutionary that most of his contemporaries regarded it as more than 20 years ahead of its time. Even years after his death, the full magnitude of its detail had not been fully utilized. Among his 128 patents are the principal electronic circuits critical to the development of the world's first electronic television system. During his short working life, Blumlein produced patent after patent breaking entirely new ground in electronic and audio engineering.

During the Second World War, Alan Blumlein was deeply engaged in the very secret work of radar development and contributed enormously to the system eventually to become 'H2S' – blind-bombing radar. Tragically, during an experimental H2S flight in June 1942, the Halifax bomber in which Blumlein and several colleagues were flying, crashed and all aboard were killed. He was just days short of his thirty-ninth birthday.

420 pages

Order code NE32

£15.99

HIGH POWER AUDIO AMPLIFIER CONSTRUCTION
R. A. Penfold

Practical construction details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. includes MOSFET and bipolar transistor designs.

96 pages

Order code BP277

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Circuits, Data and Design

PRACTICAL ELECTRONIC FILTERS

Owen Bishop

This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.

The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rhythm sequencer and a multi-voiced electronic organ.

Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.

88 pages

Order code BP299

£5.49

ELECTRONIC HOBBYISTS DATA BOOK

R. A. Penfold

This book should tell you everything you are ever likely to want to know about hobby electronics, but did not know where to ask or refer. Comprehensive contents pages makes it easy to quickly locate the data you require.

The subjects covered include: Common circuits, and related data (including helpful graphs and tables of values); Colour codes for resistors, capacitors and inductors; Pinout details for a wide range of CMOS and TTL devices, plus basic data on the various logic families; Pinout details and basic data for a wide range of operational amplifiers; Data and leadout information for a wide range of transistors, FETs, power FETs, triacs, thyristors, diodes, etc.; General data including MIDI message coding, radio data, ASCII/Baudot coding, decibel ratios, etc.

242 pages

Order code BP396

£6.45



50 SIMPLE LED CIRCUITS

R. N. Soar

Contains 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components – the light-emitting diode (LED). Also includes circuits for the 707 common anode display.

64 pages

Temporarily out of print

BOOK 2 50 more l.e.d. circuits.

50 pages

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CIRCUIT SOURCE BOOK 1

A. Penfold

Written to help you create and experiment with your own electronic designs by combining and using the various standard "building block" circuits provided. Where applicable, advice on how to alter the circuit parameters is given.

The circuits covered in this book are mainly concerned with analogue signal processing and include: Audio amplifiers (op.amp and bipolar transistors); audio power amplifiers; d.c. amplifiers; highpass, lowpass, bandpass and notch filters; tone controls; voltage controlled amplifiers and filters; triggers and voltage comparators; gates and electronic switching; bargraphs; mixers; phase shifters, current mirrors, hold circuits, etc.

Over 150 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.

182 pages

Order code BP321

£5.49

A BEGINNER'S GUIDE TO TTL DIGITAL ICs

R. A. Penfold

This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world".

142 pages

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HOW TO USE OP. AMPS

E. A. Parr

This book has been written as a designer's guide covering many operational amplifiers, serving both as a source book of circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible.

160 pages

Order code BP88

£4.49

CIRCUIT SOURCE BOOK 2

R. A. Penfold

This book will help you to create and experiment with your own electronic designs by combining and using the various standard "building blocks" circuits provided. Where

applicable, advice on how to alter the circuit parameters is provided.

The circuits covered are mainly concerned with signal generation, power supplies, and digital electronics.

The topics covered in this book include: 555 oscillators; sine-wave oscillators; function generators; CMOS oscillators; voltage controlled oscillators; radio frequency oscillators; 555 monostables; CMOS monostables; TTL monostables; precision long timers; power supply and

regulator circuits; negative supply generators and voltage boosters; digital dividers; decoders, etc.; counters and display drivers; D/A and A/D converters; opto-isolators, flip/flops, noise generators, tone decoders, etc.

Over 170 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.

192 pages

Order code BP322

£5.45

Project Building & Testing

ELECTRONIC PROJECTS FOR EXPERIMENTERS

R. A. Penfold

Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different. No doubt many of the projects featured here have practical applications, but they are all worth a try for their interest value alone.

The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

138 pages

Order code BP371

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PRACTICAL FIBRE-OPTIC PROJECTS

R. A. Penfold

While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.

The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages

Order code BP374

£5.45

ELECTRONIC PROJECT BUILDING FOR BEGINNERS

R. A. Penfold

This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc;

advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.

In fact everything you need to know in order to get started in this absorbing and creative hobby.

135 pages

Order code BP392

£5.49

A BEGINNER'S GUIDE TO MODERN ELECTRONIC COMPONENTS

R. A. Penfold

The purpose of this book is to provide practical information to help the reader sort out the bewildering array of components currently on offer. An advanced knowledge of the theory of electronics is not needed, and this book is not intended to be a course in electronic theory. The main aim is to explain the differences between components of the same basic type (e.g. carbon, carbon film, metal film, and wire-wound resistors) so that the right component for a given application can be selected. A wide range of components are included, with the emphasis firmly on those components that are used a great deal in projects for the home constructor.

166 pages

Temporarily out of print

HOW TO USE OSCILLOSCOPES AND OTHER TEST EQUIPMENT

R. A. Penfold

This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits, plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers, and crystal calibrators.

104 pages

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NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

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
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Twinkling Star	DEC '00 276	£4.28
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★PIC-Monitored Dual PSU-1 PSU	280	£4.75
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EPE FTP site: <ftp://ftp.epemag.wimborne.co.uk>

Access the FTP site by typing the above into your web browser, or by setting
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 sub-directories:

PIC-project source code files: [/pub/PICS](#)

PIC projects each have their own folder; navigate to the correct folder and open it, then fetch all the
 files contained within. *Do not try to download the folder itself!*

EPE text files: [/pub/docs](#)

Basic Soldering Guide: [solder.txt](#)

Ingenuity Unlimited submission guidance: [ing_unlit.txt](#)

New readers and subscribers info: [epe_info.txt](#)

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